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9. ABSTRACT

Presents the findings of a team of U.S. cotton experts who went to Pakistan to examine reasons for the drastic reduction in yield per acre of cotton production since 1972. A drop from 4 million bales in 1971-72 to 2 million bales in 1976-77 posed a serious economic problem to the country in general and to the agriculture and textile industries in particular. The team located the decline primarily in the upland cotton production area of the Punjab. This report includes analyses of information and data obtained by a lengthy field trip to six agricultural research locations. Assessments were made of facilities, staff capabilities, relevance of research programs and funding. The recommendations include: 1. better insect control, 2. improvement of seed quality, 3. strengthening of cotton breeding programs, 4. encouragement of ridge and line sowing, 5. establishment of a national cotton variety testing program, 6. better weed control, 7. improvement of land leveling, and 8. improvement of stands. The appendix to the report contains tables and graphs and a discussion of insects.

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COTTON PRODUCTION DECLINE IN PAKISTAN 1971-76

Prepared for:
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and
The Agency for International Development

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COTTON PRODUCTION DECLINE IN PAKISTAN 1971-76

SUMMARY

Major Problems by Priority:

1. Insect damage has been severe particularly in past two years of adverse weather and inadequate control measures.
2. Poor seed quality has resulted in poor stands.
3. Varieties need to be developed that are better adapted to weather variables.
4. Yields are reduced by broadcast sowing. Current systems must be changed to ridge and line sowing.
5. Current research programs should include coordinated national variety testing program to give accurate information on comparative variety yields.
6. Weed infestation is reducing yields significantly, particularly in seasons of heavy rainfall.
7. Unevenness of fields, results in poor water management, weeds and stand difficulties.
8. Poor stands contribute significantly to low yields.

COTTON PRODUCTION DECLINE IN PAKISTAN 1971-76

INTRODUCTION

BACKGROUND

Since the beginning of American upland cotton production in Pakistan early in this century, yields have been relatively low, considering the quality of soil, climate, and the fact that irrigation is used. However, gradual improvement in yield per acre began about 1966 and had reached a plateau of 322 pounds[1] lint average per acre nationally by 1972. Since that time drastic reduction in yield per acre have occured. In 1975-76, acre yield was about 248 pounds per acre and in 1976-77, it was even lower. As a result, the drop in bale production in the country from approximately 4 million bales in 1971-72[2] to approximately 2 million bales in 1976-77, posed a serious economic problem to the country in general and to the agriculture and textile industries in particular.

The Government of Pakistan requested the Government of the United States to send three qualified cotton experts to Pakistan for the purpose of studying the factors responsible for the decline of cotton production. Further, recommendations were to be made by the cotton team that, if implemented, could hopefully reverse the decline in future years.

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(1) Source: Cotistics - Dec., 1976, Pakistan Central Cotton Comitte. Tables 5, 6; pp. 10, 11 - Appendix.
(2) Ibid., Tables 3, 4; pp.8,9 - Appendix.

Experience, Incorporated had the responsibility of selecting the cotton team experts, giving them their assignments and making necessary arrangements for the start of the study. The Government of Pakistan, Ministry of Agriculture furnished counterpart scientists to work with the team, and USAID/Islamabad cooperated with heavy involvement in administrative support, meeting arrangements, transportation, housing and other important matters.

SCOPE OF REPORT

This report presents the findings of the study. It includes, a) analyses of information and data obtained by a lengthy field trip to six research locations, b) meetings with producers, c) provincial secretaries of agriculture, d) WAPDA (Water and Power Development Authority), and e) directors of agriculture-extension and officials of the Pakistan Central Cotton Committee.

The evaluation of research programs was done on a field trip to three major research locations. Assessments were made of facilities, staff capabilities, relevance of research programs and to a lesser extent-funding. A narrative account of the field trip is given in the Appendix pp. 1-5.

The study pinpointed the decline as being primarily in the upland cotton production area of the Punjab. Analysis of production by divisions show that while there has been some relatively slight decline in the Sind, the major national decline in the past two years has occured in the area from

Multan east to the border, west to the desert areas, and north through the Punjab cotton growing areas. There has been some decline in acreage planted to cotton in the past two years[1].

Production data also show that there has been little change in desi acreage, production or yield per acre[2].

Therefore, this report will be primarily addressed to the decline of upland cotton production in the Punjab.

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(1) Tables 1, 2; pp. 6, 7 - Appendix

(2) Tables 7, 8, 9 - Appendix

PLANT BREEDING AND GENETICS

BACKGROUND

Although plant breeding is categorized as a science, or more critically, an applied science, most plant breeders will agree that it is part science and part art. The relative proportions of the two disciplines used in prosecution of a breeding program depend on many factors not the least of which is the mental attitude or philosophy of the plant breeder. Examples too numerous to mention may be cited of the development of world-famous varieties or plant types by men who had never had a formal course in genetics, physiology, biometry, bio-chemistry or any of the other basic academic disciplines now required of university graduates in plant breeding. In such cases art was the predominating, if not the sole, vocation. Certain genetic principles undoubtedly were involved in the breeding (selection) procedures, and while they could not explain their results in terms of genetic theory, they understood such old axioms as "like begets like" and that the easiest to make crosses are between the closer related plant types. However, as improvements or developments made by early-day plant breeders, largely through the practice of the art, have been incorporated into better and better varieties, plant breeders are called upon from all sectors of the cotton industry to produce still newer types or to reach even higher levels of performance. In attempting to satisfy these demands plant breeders have had to bring science into the breeding program to an ever increasing extent. Thus, if one can predict the not too distant future

from the events of the relatively recent past, we can expect science, or scientific practice, to predominate in the breeding programs of the foreseeable future, and the modern plant breeder must be, or become, more scientist than artist. A great deal more sophistication must take place in cotton breeding methodology and a much higher level of determining significant differences among character expressions must be attained in progeny, strain and variety testing programs.

Many people in the general public seem to think that the plant breeder has some occult or mystic power over plants. Occasionally newspapers or farm journals report some "great break through" in the improvement of cotton or some other crop and no doubt some plant breeders have not been particularly modest about taking credit for all sorts of crop production advances, the greater of which, in the main, are attributable to favorable growing seasons or skillful crop management rather than to theatrical manipulation of heritable plant characters. Thus, while responsible plant breeders do not minimize what has been done, or what can be done, through plant breeding, we must be realistic about the limitations inherent in the biological material. That is to say that we cannot cross cotton with sunflowers and produce a plant with one big boll at the top.

Modern cotton varieties are remarkable cellulose manufacturing "machines" and they represent truly great feats of plant breeding. As the result of many years of careful selection and testing, the well established varieties are capable of performing at a high level of efficiency and are in a delicate state of genetic balance. In a few instances "major advances" or

"spectacular developments" have played a part in their development. But in most cases the high level of productivity and adaptability have been attained by small improvements accumulated in the breeding stock over a long period of years. Looking to the future, the plant breeder may hope for the big, spectacular advance (and a few lucky ones may actually experience such a happening), but he should not expect, or lead the public to expect, that he will make an improvement every time he handles a plant, makes a cross or isolates a selection. In fact, we feel strongly that a plant breeder, having developed a superior variety, or having had one handed over to him, will earn his keep if thereafter he can just hold or maintain the variety at its original high level of performance.

This must not be taken as a feeling that nothing further can be done to improve established commercial cottons through the application of the science of plant breeding. Quite the contrary; the field is wide open and the problems amenable to solution, at least in part, by plant breeding are almost infinite. The recent decline in yield in Pakistan has been mainly attributable to unfavorable weather, but the problem is believed to be susceptible to at least partial correction or amelioration by development, and thorough regional and national testing, of strains or varieties that will be better adapted to the adverse weather conditions under consideration.

In this section of this report we intend to emphasize practical plant breeding as it relates to the central problem that has been carefully defined and specified elsewhere in this report. Genetics and other

supporting disciplines will be mentioned and dealt with only to the extent that they may enhance the plant breeding programs contributing to the central problem, i.e., distressingly low yields.

At least three-quarters of a century ago, British cotton scientists had reached the conclusion that cotton breeding offered the single most practical approach to cotton improvement in areas where the greater part of the total cotton crop was produced by farmers who cultivated small acreages. The rationale, in general, was that such farmers seldom had the resources or the managerial capability to maximize production by so-called "technical" farming practices. But, in their view, the small landholder, even though he did not employ the best cropping methods, could benefit at least to some extent, by inherent improvements in yield, plant resistance to pests, etc. which are brought about through plant breeding. Whether or not this concept has had an infuence on cotton breeding research in Pakistan, it is well known throughout the cotton growing regions of the world that plant breeding occupies a prominent place in the hierarchy of agricultural research in this country, and that comprehensive cotton breeding programs are currently being prosecuted at a relatively large number of institutes and experiment stations. We find no grounds for questioning the continuation of strong support of sound cotton breeding programs and would, at this point, only call the attention of the plant breeders, as we did earlier in this section to the importance of the vital role of strain and variety testing in all plant breeding programs, and the need for objectivity and self discipline in the part of operating scientists.

PROBLEMS AND OBJECTIVES

Immediate Problem

Keeping in mind that the main problem to which this team has been instructed to address itself is the low national cotton yields of the past two years, an important question, from the plant breeding standpoint, is whether or not cotton varieties have contributed significantly to this recent drastic yield decline.

In a few instances, during the course of our trip through the cotton growing regions, we heard the claim that the seed of the currently approved variety grown in a particular area had deteriorated. It has been difficult to determine what is really meant by that term, but apparently it can mean mechanical mixture with other seed stocks or actual genetic deterioration of the variety in question or both. Mechanical mixture of planting seed stocks has been dealt with in the agronomy section of this report. We raised the question of adverse genetic changes (deterioration) with every cotton breeder and every geneticist with whom we have visited in Pakistan and all were convinced that the low yields of the past two cotton growing seasons are not attributable to genetic deterioration of commercial varieties to any measurable or significant extent. We were shown data to support this opinion. Additional evidence that varietal deterioration has not been a contributor to recent low yields is given by the fact that during the low-yield period in point, there were occasional farmers in various parts of the affected area whose cotton yields had been

normal, i.e., up to the average yields obtained prior to the past two crop seasons. Finally, there are theoretical grounds for feeling that genetic deterioration could not have been a significant contributor to recent low yields. In the introduction to this section, reference was made to the fact that improvements in cotton are nearly always made in small increments over relatively long periods of time. By the same token (and particularly when the plant breeders have not made radical changes in their breeding methods or the stocks or varieties made available to farmers - as has been the case here), lowering of yields would also be time consuming and slow - so slow in fact that they could not have been a significant contributor to the low yields of the period in question.

Weather in Relation to Plant Breeding Objectives

It has been generally concluded that the low yields of the past two cotton growing seasons have been caused by weather factors operating well beyond the range of normal expectancy. Of the weather or climatic factors that may have been involved, excessive and untimely rainfall appears to have been the major contributor. Some of the people with whom we talked (certain farmers and agricultural extension workers in particular) seen to believe that the cotton growing region of the Punjab has undergone a major change in climate that will persist. Others, and in our view, the majority - seem to feel that the recent years of high rainfall are simply fortuitous events in the weather regime and that a dryer phase of the weather cycle inevitably will materialize. Members of this team certainly do not intend to make any kind of weather prediction, much less a period-of-years weather

forecast. But from the standpoint of the plant breeding programs in Pakistan, the weather (rainfall and temperature) question appears to be a matter of degree and should not cause much, if any, change in the principal breeding objective which we understand is to maximize yield and yield potential.

Growing Season - Punjab

In reference to the Punjab (where the greatest recent yield depression has been experienced), the information given to us verbally, as well as in the form of data, provided the following general or broad picture of the cotton growing season: 1) Following the harvest of a winter crop (usually wheat) and the necessary preparation of the land, cotton is sown from mid-May to mid-June. Rainfall ranging from light showers to fairly heavy downpours may or may not occur during this period. Rainfall during this period can cause crusting of the soil which, in turn, often results in low plant populations and poor stands, and may, under severe conditions, necessitate replanting or abandonment. One of the most universally accepted principles of cotton production is that poor stands condition poor yields. 2) A period of high temperatures occurs from mid-May through the first part of July. There was no solid consensus among the cotton scientists and specialists with whom we visited about the affects of this period of hot weather on cotton plant growth and fruit setting. The majority, however, seemed to believe that during this period there was excessive shedding of fruit forms in cotton planted during the "normal" period just mentioned. Furthermore, in their opinion, cotton planted at an earlier period and entering a boll

setting stage during this hot period gave premature opening of bolls and "tight" locks, if indeed the young bolls were not aborted. 3) The period extending from mid-July to the first part of September, often called the monsoon season, is characterized by light to torrential rains. Depending on the favorable interaction of a host of biological, cultural and management practices, a small to a considerable number of fruit forms may be set during this period. 4) The peak period of fruit formation and boll set generally occurs in the six to eight weeks of favorable weather following the rainy season. 5) Harvesting usually begins the last part of November and may extend beyond the beginning of January.

Major Breeding Objective

Even though the environmental factors encountered during the crop season as discussed in the section above, may be formidable, a considerable corps of cotton breeders (botanists) are currently engaged in research which has its major, overall objective the maximization of cotton yields under the climatic conditions that prevail in the major cotton growing regions. Of course, each and every cotton breeder is not working on every conceivable plant character or genetic procedure that could possibly contribute to the achievement of the total objective. Of necessity, the job has to be attacked in small increments. In the section to follow more will be given about the desirability of coordinating the individual research effort.

Other Breeding Objectives

Breeding objectives which may not be considered to be a direct part of the broad crop-climate objective just described are: plant resistance to

insects and diseases, and improvement of fiber properties and spinability. These objectives will be discussed later.

BREEDING PROGRAMS AND RECOMMENDATIONS

Maximizing Yields Under Varying Weather Conditions

Reference has been made earlier to the substantial and comprehensive cotton breeding research in Pakistan that is being directed toward this objective. It was also pointed out that for obvious reasons every individual cotton breeder will not place equal emphasis on each and every aspect of the total breeding problem, nor would all breeders use the same methods and breeding approaches. This, we feel, is as it should be for we do not advocate the adoption of a single standardized breeding method. Rather, we believe the breeding methods should be designed for the most efficient prosecution of the problem at hand and contain flexibility enough to provide revision when biological or economic problems so indicate.

Bearing in mind that quick, spectacular solutions to the problem of low crop yields are not to be expected from plant breeding, the problem appears to be of such economic and sociological importance as to justify a strong plant breeding effort directed toward aiding or participating in its solution. Here again we emphasize that well designed, carefully executed and objectively interpreted field performance (yield) tests of strains and varieties are an essential part of a breeding program, and we strongly recommend that the performance testing phase of cotton breeding at all

levels and in all locations receive more critical attention and support. Therefore, we urge the continuation of the current plant breeding programs and recommend that scientists with the best possible training and experience be employed in the breeding programs. We also recommend that the various research (breeding and genetic) efforts be more clearly identified or described in terms of their proposed contribution to the solution of the total problem; and we strongly recommend that the research effort on this admittedly difficult problem be functionally coordinated at the national level, if possible, but hopefully no lower than the provincial level. Among the reasons for recommending such coordination are: 1) to develop a better understanding of the resources available, 2) to commit these resources efficiently, 3) to identify components of the total program that need to be strengthened, and 4) to avoid needless duplication or repetition effort.

Other recommendations in regard to cotton breeding programs are given in the paragraphs to follow.

National Variety and Strain Testing

In our opinion, all segments of the Pakistan cotton industry would benefit from cotton performance (yield) test designed in such a way as to provide valid statistical comparisons of the principal varieties currently supplied to farmers. Test should be made annually in each of the major cotton growing regions of the country. They need not be uniform or fixed in terms

of the number and kind of entries so long as a small number (preferably not less than three) of "standards" be included in each test on a nation-wide basis. At the provincial or even the division level, the national standards should be supplemented by another and somewhat larger number of standard test varieties. At both the national and lower levels the standards should remain in the appropriate tests for at least three years. And, most important of all, the tests should be conducted annually over an indefinite period of years.

At first glance such a testing program might appear to be formidable. Experience in the United States has shown that this is not the case. Little, if any, extra work falls on the individuals who conduct the tests because in actual practice the national test at worst requires only the insertion of a few more entries into the regular station performance tests that plant breeders traditionally conduct, such as shown in Table 10, page 15, Appendix. The key to the success of such a program is simplicity. Avoid complicated test designs and hold to the three prime variables: varieties (or strains), locations and years.

The main advantage of such a systematic, though simple, testing program is that the cotton breeder (or any other interested party) can obtain valid estimates of the performance of currently grown varieties (including foreign varieties of interest if they are deemed to be worthy of inclusion in the test design), when grown at different locations over a period of years.

Numerous other uses can be made of national variety test data. For instance,

assuming the pertinent varieties had been entered in the test, the current controversy over whether or not a certain early maturing - rapid fruiting foreign variety is superior in yield performance to locally developed varieties could no doubt be resolved by a study of the test data. Such data also might shed critical light on what appears to be a fairly common practice of breeding special varieties for relatively small "ecological zones". Study of data from a variety testing program such as that recommended here might well identify varieties or strains with such broad adaptation capabilities that the need for certain breeding and planting seed programs designed to serve some of the smaller ecological zones could be terminated or integrated with other breeding programs of higher priority.

Genotype-Environment Interaction

Breeding for high varietal yield under varying climatic conditions involves the concept of establishing general or broad genotype adaptability to total environment (particularly the weather) to be encountered during the crop season. In the United States, in addition to the term genotype-environment interaction, studies in this field are also referred to as crop-climate investigations - or simply as bioclimatology. Regardless of the terminology, the general principle involved is to attempt to discover valid associations between certain known genotypes (in the form of varieties, strain, breeding stocks, etc.) and certain measureable or describable features of the weather. Research in this field can provide strong support to research in adaptation to the total climate mentioned earlier and may well supply direct inputs to such breeding programs.

For instance, a crop-climate study of the relationship of earliness of maturity to seasonal rainfall and temperature would, in a simple design, involve a small number of genotypes known to range from very early maturing to very late maturing. These genotypes or stocks are planted periodically in a series of planting dates that range from early season to late season. As the crop begins to mature, a stratified harvesting system should be employed to measure earliness of maturity. Stratified harvest simply means that each individual test plot that contains open (mature) cotton is harvested on the same day (or consecutive day) on at lest two (and preferably three or more) stages or periods during the crop maturing season.

There is an active interest in research in bioclimatology in the United States, and we note that some very good research of this kind has been made at the Cotton Research Institute at Multan.[1] We do not advocate such experimentation at each and every cotton station in the country, but we do recommend research of this kind at a limited number of key stations or institutes.

Bulkcrossing

As breeding problems have become more complex, it has become necessary to range further afield in search of suitable plant characters. Often the desired character is found in wild, primitive or noncommercial cotton stocks (or species). In theory the backcross method of plant breeding would appear to be an ideal system for transferring a desired character

(1) Munir-ud-Dir, Abdus Salam and Mehboob Ali. Some observations on the Effects of Date of Picking on Different Characters of Cotton, Gossypium hirsutum L. Journal of the Pakistan Central Cotton Committee, 17:3, pp. 73 - 104. April, 1973

from a noncommercial stock to an established commercial variety. However, in actual practice in cotton, the backcross method has been successful only in those few cases where the character to be transferred is conditioned by a very limited number of genes. Unfortunately, most characters of economic value in cotton are conditioned by a large number of genes. In our experience, transference of such characters by the backcross method has been generally unsuccessful and unsatisfactory in terms of developing commercially accepted varieties. For manipulating genetically complex characters in a breeding program we recommend any of several systems of bulk, mass or polycrossing which are designed to reconstitute a balanced, potentially productive genotype around the economic character or characters under primary selection pressure. A somewhat more complicated breeding system called recurrent selection also is recommended for the purpose just described.

Germplasm Collection, Cytogenetics

Modern plant breeding programs require access to and the support of comprehensive sources of genetic variability. Such sources, in genetic terminology, are often called germplasm pools or germplasm collections. Plant breeders, or plant breeding programs will no doubt be the principal users of a germplasm collection for they are in constant search for, and in need of, genetic characters of potential economic value.

A comprehensive germplasm collection has been developed as part of the research program at the Cotton Research Institute at Multan. This

collection contains many of the species of cotton (Gossypium) and exotic cultivated stocks as well as a large number of noncultivated types. A cotton collection, emphasizing the species of Gossypium is being maintained at the Sind Agricultural Research Institute and used in the cotton breeding program. In fact, we were told that a wild species native to Africa (G. anomalum) had contributed certain useful characters to a recently developed commercial variety. Also, we were told that a germplasm collection will be established at the Cotton Research Institute now being developed at Sakrand.

While cotton breeders (botanists) working in experiment stations in the various districts of the Punjab and Sind should obtain and maintain the types and kins of primary breeding stocks required for the breeding programs currently in progress, we feel that comprehensive and extensive collections of germplasm should be restricted to the two Cotton Research Institutes mentioned - one in the Punjab and one in the Sind. We suggest that attention be given to keeping the germplasm collection current in terms of worldwide development of new and improved cotton stocks. In this connection, we recommend that one or both of the Institutes try to obtain certain of the so called rapid fruiting types now of great interest in the United States. Furthermore, we strongly recommend that active cooperation and a free and continuing exchange of information be developed between the two Institutes with particular emphasis on practical division of responsibility and labor with respect to stock procurement, development, maintenance and distribution.

If breeding programs require the transference or introgression of special characters found in wild species, the services of a well trained cytogeneticist will be required to produce the necessary interspecific hybrids and carry out the polyploid procedures required in the development of a useful primary breeding stock.

Disease Resistance

Reference has been made elsewhere in this report to the feeling held by most cotton scientists that, historically, diseases have been relatively minor contributors to the reductions in cotton yields in Pakistan. The team is of the firm opinion that cotton diseases have not been a significant factor in the serious yield declines of the past two crop years. Though it is relatively innocuous when compared with its damage to cotton in Africa and certain other cotton producing areas, the information supplied to us shows that the bacterial blight disease causes slight to considerable damage to the Pakistan cotton crop in certain production areas and under localized weather conditions. Fortunately, bacterial blight can be controlled within practical limits by rather simple plant breeding methods. In fact, the development of genetic resistance is believed to be the only practical method of controlling the disease. Blight resistant breeding stocks are widely available to breeding programs everywhere. In the cotton producing areas of Pakistan, where bacterial blight is known to be a problem, plant breeders have as one of their objectives, the development of bacterial blight resistance in their advanced breeding stocks. We recommend that care be taken to place high resource priority

on bacterial blight resistance research programs only in those areas where there is a reasonably high probability of the disease causing serious damage to the cotton crop. Therefore, we recommend continuation and strenthening of bacterial blight breeding programs now in progress in those areas where the disease is known to be critical.

Insect Resistance

The idea of developing host plant resistance to insect damage has intrigued plant breeders and entomologists for years; but in spite of the great amount of research that has been expended on attempts to establish economic or practical levels of plant resistance to insects, there are very few cases of success. Among this elite group is the example of the development of cotton plant resistance to jassids at the Barberton Station in South Africa some fifty years ago by breeding plants with copious hairs on their leaves. In addition to this classic case of jassid resistance, writers on this subject usually mention the example of the "saving of the U.S. cotton industry" in the 1920's by plant breeders who developed early maturing varieties that were able to set and mature an acceptable crop of cotton before the onset of the peak period of attack of the cotton boll weevil. Within the past 10 to 15 years in the United States, there has been a resurgence of interest and activity in biological control of cotton insects. The broad field of biological control, of course, involves breeding for plant resistance as an important constituent. The most note-worthy finding, in the recent insect resistance research in the United States, has been in

connection with the development of new short-statured, rapid-fruiting types primarily for the purpose of obtaining more efficiency and economy in the mechanical harvesting of the crop. Certain field tests, however, revealed that some of these rapid fruiting types had the capacity to evade major insect damage by making a crop before insect populations reached damaging numbers. This recent experience is similar in principle to the experience with the early maturing varieties of the 1920's. The generally poor record in respect to discovering actual physiological or biochemical (toxic) hostplant resistance must not be interpreted by administrators of agricultural research organizations as being so unpromising that efforts in this field should be discontinued. We know from experience and from the published record that the odds against success are enormous. If the task had been easy, plant scientists or selectors would have solved the insect problems long ago. Nevertheless, the economics of controlling cotton insects solely by chemical methods are such that the cotton industry worldwide, cannot afford to relent in its search for plant resistance to the major kinds of insect pests.

During our field trip, we learned that practically every cotton breeding program in the Punjab and most of theprograms in Sind had as one of its objectives the development of a practical degree of jassid resistance into advanced breeding strains and varieties to be distributed to farmers. We were given the understanding that jassid attack or damage, historically, has been considerably less severe in Sind, but on occasion has been a problem in certain areas. We recommend continued emphasis on developing practical levels of host-plant resistance to jassids in the varieties to be released in any of the cotton growing regions of Pakistan where economic

damage by this insect is to be expected on an annually recurring basis.

As for research on resistance to harmful insects other than the jassid, we urge that to the extent that budget and research priorities will allow, the plant scientists of the principal Institutes in Pakistan join their colleagues abroad in the struggle to discover practical sources of host-plant resistance to insects and develop insect resistant breeding stocks.

Planting (Sowing) Seed

On occasion, during our discussions with agricultural officials, the question of the advisability of importing large quantities of planting (sowing) seed from the United States or other foreign cotton growing areas was raised. Earlier in this section we recommended the establishment of a comprehensive program of field-performance testing on a national scale. Such tests should include the recently developed foreign varieties or stocks that have been reported to be top performers in their country or area of origin. For emphasis, we repeat this recommendation regarding the implementation of a comprehensive national cotton variety testing program. When data from such a testing program, collected over a period of three or more years are analyzed and interpreted, a much firmer and more reliable basis will have been established for official decisions on the feasibility of importing cotton planting (sowing) seed in large quantity.

PLANT PROTECTION

INSECTS

Background

Cotton fields are inhabited by a great variety of insects and spider mites. Some are beneficial in that they are parasites or predators of insect pests of cotton; others (more than 100 species in the world) are direct pests of the crop. No cotton fields are free of insects but the species and their abundance vary greatly, depending on the weather and other environmental conditions.

Some insects attack cotton in the seedling stage, others feed on the fruiting forms, and still others feed on the stems and foliage. Those which pass the larval cycle within squares or bolls are well protected from parasites and insecticides and are our worst pests. Examples of these are the bollworms.

Cotton farmers in Pakistan are well aware of the damage insects can cause and the difficulty of controlling them. It is essential to protect cotton from insect damage if it is to be a profitable crop.

We were requested to determine the cause of reduction in cotton yields in recent years. In our discussions with farmers and agricultural scientists, we learned that insects have caused great losses and are difficult to control.

We reviewed research and extension activities to determine what information is available, and if it is reaching the farmers. It is obvious that something is wrong and farmers are not controlling cotton insects. The resulting loss due to insects is a major cause of the recent reduction in cotton yields.

Important Insect Pests

Growers and scientists told us that the following insects are serious pests of cotton in Pakistan: cotton jassid, cotton whitefly, pink bollworm and potted bollworm. In addition, the following insects are ocassional pests: cotton aphis, *Heliothis*, termites (white ants), black-headed cricket, spider mites, and leaf rollers.

Nature of Insect Injury

Crickets and cutworms cut off and kill young plants. Sucking bugs feed on terminal growth and small squares, causing the plant to be bushy and lacking in fruit. Some worms feed on terminal growth and may tunnel into stems, making the plant appear to have been topped. Jassids and spider mites feed on leaves destroying the chlorophyll and causing the leaves to curl and appear dry. Other insects feed on or in fruiting forms, causing them to shed or, in the case of the pink bollworm, one or more locks may be destroyed while the others may produce harvestable crops.

Weather and Insects

Farmers have long known that cotton insects cause more damage in rainy than dry years. Conversely, profits are usually higher in dry years when insects and weed control costs are lowest.

Insects such as jassids and aphids thrive best under wet conditions. *Heliothis* deposits more eggs and there is a higher survival of larvae on succulent, rank cotton. Also, it is more difficult to apply and keep insecticides on cotton during rainy weather.

The pink bollworm favors dry weather, particularly during the winter and spring seasons when long cycle larvae are hibernating. Also, the short cycle larvae pupates in the soil and are subject to certain hazards following rains and irrigation.

Insects destroy fruiting forms and cause the plant to grow rank, further adding to the difficulty of controlling insects during rainy weather.

Principles of Insect Control

Under ideals conditions there is a biological balance among insects. Predators, parasites, and diseases play an important part in preventing destructive infestations of cotton insects. Unfortunately, biological control cannot be relied upon to control cotton insects. Beneficial insects and pathogens may be added to supplement the native population or

insecticides applied to control the pests. Most insecticides kill the beneficials as well as pests. The important point is to carefully check the cotton for all insects and make maximum use of native populations of parasites and predators as long as possible before starting the chemical control program.

The general principles of cotton insect control are applicable throughout the world even though different insect populations and ecological conditions exist in all fields. Guidelines, quoted verbatim in the following paragraph, were included in the 30th Annual Conference on Cotton Insect Research and Control in the meeting of 117 cotton entomologists and other public officials in Atlanta, Georgia, on January 10-12, 1977. The 74 page report is available free to anyone requesting it from the Bioenvironmental Insect Control Laboratory, U.S. Department of Agriculture, Stoneville, Miss. 38776.

"Determining the species and abundance of various insects and the specific injuries inflicted upon the cotton plant is important in insect control. Knowledge of the life history and habits of the insects, the growth and fruiting characteristics of cotton plants, and the environmental relationships that exist between the plants and insects yields additional information basic to an evaluation of the economic insect situation involved. Each control measure used should be a part of an integrated control program, utilizing to the fullest extent wherever possible cultural, physical, mechanical, biological, legal, and natural controls. However, when the level of infestation of an insect or group of insects approaches the economic threshold, chemical control measures whould be applied to prevent

damage to the cotton crop. Insecticides, dosages, formulations, and timing schedules should be selected to solve existing problems without creating new ones."

Determining Need for Insect Control

The need for insecticidal control of cotton insects should be based on field inspections and infestation counts of the injurious species, taking into consideration the abundance of parasites and predators, growing conditions, potential yields, and economic benefits to be gained from insect control. Automatic application schedules based on calendar dates or size of the cotton plant, without knowledge of infestation levels, is wasteful of insecticides, destroys beneficial insects, results in buildup of *Heliothis*, aphis and spider mites, and hastens the development of insecticide resistan populations.

The determination of pest populations throughout the growing season is essential in carrying out a profitable control program. Checking cotton for insects requires considerable knowledge of entomology and cotton production. Some farmers do not have the time nor the knowledge to make the field inspections. They may employ cotton checkers to do this job throughout the season. This practice may be paid for by saving one insecticide application when not needed or by applying insecticide when justified by population counts but would not be done on a scheduled basis.

We believe that there are a few entomologists in Pakistan who know cotton

insects and how to control them. There are many who could be trained to check cotton and determine insect conditions in the field. The nucleus for developing an effective cotton insect inspection program is present in Pakistan. It should be started on a small scale in a productive area where the farmers are progressive and desirous of making maximum profits from cotton. The farmers would pay most, if not the entire cost of the scouting program — just as they pay other production costs.

The success of a scouting program will depend on the technical and practical knowledge of the entomologists and the willingness of the scouts to make accurate infestation records and the ability of the farmers to carry out the recommended practices. It is recognized that profitable insect control in Pakistan will require unusual talent and skill. The laborers must be trained to apply highly toxic materials with crude hand sprayers. Scouts must be energetic and reliable, and farmers must be progressive and desirous of making meximum profits from cotton.

Aerial Spraying

Several growers told us that aerial cotton spraying programs done by the public sector was not effective and it was their opinion that it should be discontinued even though the material and its application was free to the grower. It seems that the time and number of applications were based on calendar dates and not insect infestations and the application was poorly done.

U.S. entomologists recommend flagging the swaths, flying the plane at five feet above the cotton, and making ultra low volume swaths at 35 to 75 feet depending on the weather. Dust applications should be made at not more than 40 foot swaths.

It appears that a high percentage of the fields are too small or have too many trees and power lines to permit the use of fixed wing airplanes to be used in applying insecticides. Special attention should be given to avoiding insecticide drift to crops being grown for human or livestock feed, to water used for drinking purposes or fish production, and to workmen in fields. It will be a short-sighted policy to use the planes just to keep them busy and to build up a fleet.

Ground Spraying

We were told that some farmers use tractor mounted power sprayers to control cotton insects with satisfactory results. These growers had relatively large acreages and their fields were large. Other growers with small fields used pressure hand sprayers. The important factor is to plant the cotton in rows, preferably on beds, to facilitate the use of spraying machinery.

Experimental results show that yields can be increased greatly -- perhaps doubled -- where insects are present in harmful numbers and controlled with insecticides. The secret of success is to apply the insecticides properly, use the correct material when infestation counts show it is needed

and repeat applications as necessary based on additional infestation counts.

INSECTICIDES

Highly efficient cotton insect control started with the development of organic insecticides about 1940. The early success of insect control with DDT led many people to feel that insect control would no longer be a problem. By use of DDT, some beneficial insect species were destroyed, thus creating a biological imbalance. Then certain innocuous species, not susceptible to the compound, became highly destructive. Other organic insecticides were introduced with the hope of overcoming these difficulties, but they too had shortcomings.

Insect resistance to some insecticides began to appear about 1950 and it was found that some of the insecticides were highly toxic to man and contaminated the environment. Twenty-seven species of cotton insects have developed resistance to one or more insecticides in the U.S. Further research to integrate all insect control techniques now show that it is possible to profitably control cotton insects.

Recommended Insecticides

Some insecticides are highly specific against certain insects while others have a broad spectrum of effectiveness. In the U.S., only three materials are registered for use against the pink bollworm, (azinphosmethyl, monocrotophos, and carbaryl) while for *Heliothis* nineteen insecticides or

mixtures will control this pest. These include six organochlorine compounds, four organophosphorous, and three others. A total of thirty-two insecticides are recommended in some states for use against one or more cotton insects. Ghouri[1] has greatly simplified the problem by selecting only sixteen insecticides to be used on cotton in Pakistan. These include DDT, but not methyl parathion and endrin.

We note that a wide variety of insecticides are used in cotton experiments in Pakistan with usually a different one in each experimental application. Hopefully, this is done to avoid insects developing resistance to any one insecticide. However, it is costly to conduct the research necessary for registration of an insecticide and the importation and storage problems are difficult.

Registered Materials

Each province has standard procedures for testing and registering insecticides. The Plant Protection Department of the central government also has registration and label requirements that must be met before an insecticide can be sold throughout Pakistan. These restrictions tend to assure high quality insecticides. However, most insecticides are bought in large drums and are transferred to unlabeled containers for distribution to farmers. This practice is unsafe, could result in contamination, use of improper materials, low quality, and should be discontinued.

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(1) Ghouri, ADK 1974, Selection of Safer Pesticides for Cotton Crop. Bureau of Agricultural Information, 50 Aryanagar, Samanabad, Lahore.

Application Methods

Most insecticides commonly used for control of cotton insects can be formulated into either sprays or dusts. They are about equally effective in controlling insects when applied properly. Sprays are usually used as emulsifiable concentrates or wettable powders. The important thing is to get good coverage and to apply the correct poundage of toxicant recommended to kill the target insect.

Airplane, tractor mounted or hand sprayers can be effectively used in applying insecticides under favorable conditions. Small sized fields and obstacles such as trees and electric lines limit the use of airplanes. Narrow rows and rank cotton make it difficult to use tractor sprayers without serious plant damage. Farmers should plan for insect control in planting, cultivating, and irrigating the crop.

We got the impression that intervals between applications of insecticides was determined entirely from the calendar or some other fixed schedule; usually at about 15 day intervals. We cannot stress too strongly that all applications should be based on knowledge of insect pests in the cotton field and this can be gained only by checking and making infestation counts before insecticides are applied.

It has been estimated that only about fifteen percent of the cotton was treated for insect control and the results were often disappointing. Had the entire cotton acreage been properly treated as needed, based on

infestation count, the yields would have been much higher.

Small fields present a special problem in controlling insects due to the cost of a sprayer and the difficulty of making adequate infestation records to determine when to apply insecticides. Yet, untreated fields present a hazard to other cotton in that they are a breeding ground and a source of infestation for the surrounding area. The small size of average farms may be one of the greatest deterrents to profitable cotton production in Pakistan.

DISEASES

Background

In general the economic importance of cotton diseases, in tropical and subtropical climates where cotton is produced, is relatively minor. Pakistan is no exception to this general situation. There are only three diseases of consequence in the country. They are bacterial blight (*Xanthomonas malvacearum*), root rots (*Rhizoctonia* spp. fusaria species and perhaps one or two more species), and boll rots.

Bacterial blight is sometimes serious in localized areas following summer rain and wind storms. Volunteer plants in the fields can carry the source of infection. The casual organism can also be carried on cotton seed and other plant residues.

Root rots occur endemically, usually on mature plants. Economically, root

rots are unimportant in the country. Boll rots usually follow insect (boll worm) attack and will be less prevalent with better insect control.

Control

Breeding of bacterial blight resistant varieties using well known, highly effective and available germ plasm, is the easiest form of control. It has been successful in many countries including the Sudan and USA.

Chemical methods are not effective although acid (sulphuric or hydrochloric) delinting will control seed borne infection. Such treatment tends to be nullified where infectious plant residues from previous crop and volunteer plants are present in new crops.

There are no known controls for root rot causing diseases.

Better insect control, particularly of boll worms, leads to less boll infection by boll rotting fungi. Another factor that will reduce boll rot losses is to use the proper management to give minimum vegetative growth of the cotton plants.

AGRONOMY

Background

Agronomy might be described as the science of successful crop production

by utilizing in a well balanced program all the factors involved in production. Good agronomic research has been one of the weak disciplines of the agricultural research institutes and stations. It not only needs to be strengthened but must be an integral part of the research program planning as related to other research disciplines. Physiology, pathology, breeding (botany), soil science, irrigation and entomology research projects should be on a cooperative working basis with the agronomy specialists. An important deficiency at all research locations is that of good mechanic support. Such support would add greatly to the maintenance of mechanical equipment and development of specially needed equipment.

Good agronomic research results lead to sound cultural practice recommendations. When such recommendations are based on results that have been demonstrated by farm trials to be effective, the extension personnel have information that when used by growers, gives better production results on a commercial scale.

Land Preparation

More tractors (60,000 - 70,000 in country) [1] are used for this operation than previously. Obviously, land can be prepared better and more rapidly by tractor than with animal power. Even so, land can be adequately prepared with animals and economic resources dictate methods. The destruction of cotton stalks and ploughing under of the infested bolls is

(1) Source: verbal communication - GOP.

one of the best methods of controlling the pink bollworm. Following ploughing, the soil is usually left in a rough, cloddy condition, with a field surface of locally uneven condition. Ploughing is usually followed by boarding. This tends to break some of the clods and improve the grade slightly.

Level land is extremely important as it governs to a great extent the proper irrigation (dosage) for planting. Much more attention should be given to the improvement of ground level in a given field prior to irrigation.

Pre-Planting Irrigation

This operation sets the pattern for the steps to come. Fields that are not properly irrigated will have some areas too wet and, more importantly, others will have inadequate moisture for seed germination. Poor germination will result in poor stands (low plant population) which results in low yields.

Sowing

Recommended sowing rate is 10 to 12 seers (about 24 pounds) per acre. Farmers generally use about one-half the recommended rate. The low rate of seeding plus low quality seed gives plant stands that are too low for optimum potential yield. One reason given for low sowing rates is that there will be less thinning required.

Line sowing is generally recommended by the research and extension personnel. However, a relatively high percentage of the acreage (70% or more) is broadcast (flat). Broadcast sown seeds have difficulty in germinating, particularly if showers occur following sowing. This can lead to soil crusting, causing poor stands or replanting, thus delaying the crop and reducing yield.

Ridge sowing in lines is rarely used. This technique offers not only potentially better stands, but also easier weed and insect control and perhaps, more importantly, drainage of water from the plants following heavy rainfall or excessive irrigation applications. It is recommended that ridge sowing be strongly advocated by research and extension personnel.

Date of Planting

Approximately 70% of the cotton sown follows wheat harvest, land preparation and pre-planting irrigation. This constraint dictates that most of the crop cannot be planted until mid-May or later. All of the cotton in a community should be planted in the shortest possible time. This shortens the growing period and reduces the time insects can multiply and attack the crop.

Stands

A good stand is one of the most important factors affecting the outcome of

final production in cotton farming. Obtaining a good stand is a difficult part of the farmer's program. It is affected by land preparation, land level, quality of planting seed, planting (sowing) rate, pre-planting irrigation, unseasonal rains after planting. and sowing methods. Recommended plant populations per acre range from 15,000 to 20,000.[1] Average populations on farms are said to range from 6,000 to 8,000. Other cultural practices cannot compensate for inadequate plant populations.

Seed quality will be discussed in a separate section. The importance of good stands cannot be emphasized too heavily.

Sowing dates are somewhat earlier in Sind and Punjab. Date of sowing is controversial both with farmers and research workers. It is obvious that currently recommended varieties will not begin to produce a crop before late August - early September. This results in frost damage to the late portion of the crop.

Fertilization

Good research has been done on fertilization requirements of cotton in the country and there are no good reasons to question the recommendations. However, the actual use of fertilizer is apparently not in accordance with recommendation. The general recommendation of 50 pounds per acre of nitrogen

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(1) Source: Agricultural Research Council: 3 - Field Crops - Cotton Documentation Center, May 10, 1974.

on cotton following"berseem"or fallow, and 75 - 100 pounds following wheat is usually exceeded by the progressive farmers and not reached by the average small farmer.

Irrigation

Cotton requires from 30 to 40 inches of water during the growing season. The total amount will depend on soil type, climatic factors - particularly rainfall and, to some extent, varietal types. Too little water during the growing season, limits growth and production. Frequently, farmers over-ittigate cotton. This may be due to several factors, but one is the fact that farmers often irrigate when the soil is already saturated because the water is available and they do not wish to pass up an irrigation. Such practice can be quite harmful to production. One general criterion for the need for irrigation is that when the upper leaves of the plant feel warm to the touch, the plants need water. Cotton plants should never be allowed to wilt.

Withholding of the first irrigation to try to force the roots to grow deep is based on a fallacy and is a counter-productive practice.

Better management of valuable irrigation water resources is badly needed and will require a much more effective extension effort to improve current practices.

Salinity and Water Logging

Many studies have been done by various groups on these serious problems in the country. Some areas, such as the Lyallpur Division, have decreased cotton acreage in recent years. The decrease is related to salinity and water logging and other factors. Some crops such as sugar cane are more profitable. There is little the farmer can do on his own to combat this problem when it becomes serious. Some of the tubewell efforts in the SCARP areas have been quite effective in lowering the water table. Ridge planting would be of considerable benefit, particularly in obtaining better stands.

Weeds

Weed infestation in cotton can drastically reduce production. Carefully conducted research experiments in the United States have shown that heavy weed populations can reduce production up to 50%. Some of the agronomists recognize the importance of weed control and strongly recommend weed elimination from fields. Farmers hand weed until the cotton plants reach a height of 3 to 4 feet. Rainy weather during the monsoon season makes weeding difficult. Also, many small farmers wish to keep some of the weeds, particularly the grasses, for animal fodder. Line or ridge sowing would permit the use of intercultivation for weed control. There are many types of simple cultivators used in the world which could be produced locally. These would be effective for animal power use and greatly reduce weed competition with cotton.

Over-all Crop Production Management

In the foregoing sections, information has been presented on cultural practices and the role that each plays in successful cotton production by farmers. Good farming practices with successful outcome invariably depends on the balance in the use of the many cultural practices. As an example, if a farmer uses the maximum recommended (or higher) rate of nitrogen fertilizer, high rates of irrigation water and does not properly control weeds and insects, the result will be excessive plant growth, greater insect problems, late maturity and poor production. Likewise, excessive insecticide use, the wrong insecticide, poor timing of application and inadequate application can create far many more problems than (was the case previously), no control effort at all.

Extension efforts to teach and demonstrate good balanced cultural practices have been inadequate and largely ineffective. More will be said about extension in a later section.

PLANTING SEED QUALITY

It is axiomatic that no crop can be better than the seed from which it is produced. Quality of sowing seed has been a perennial problem in Pakistan cotton production. The problem has been recognized by GOP officials and cotton botanists, as well as by the farmers. Several studies have been

made on this problem, [1] [2] [3] and recommendations have been made on policies and programs to alleviate the problem. A new Seed Corporation has just been established which will have the responsibility of seed increase at all levels through certified seed. It will also handle maintenance, storage, and distribution of the seed. This is an ambitious and highly desirable move to improve sowing seed quality. It should be pointed out that a successful program in cotton seed production will require many trained personnel, processing plants, storage facilities, transport capabilities and 'extreme dedication' on the part of employees. If the goals of producing adequate quantities of high quality, genetically pure seed can be obtained, some of the stand and yield problems will be relieved.

The team urges that the greatest care be taken to maintain the genetic purity of basic seed stocks for varietal increase. It also urges that every effort be made to prevent admixtures of seed, whether from desi types or other upland varieties. Admixtures can occur at picking time, before ginning, during ginning and after ginning, and in seed handling and storage. Care should be taken to preven cross-pollination with other varieties during the first two increase stages from nucleus seed forward. Cotton can be and often is cross-pollinated by pollinating insects (mainly hymonoptera) but never by wind.

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(1) International Bank for Reconstruction and Development: Report No. 718a-PAK, Pakistan - Appraisal of the Seed Project.
(2) FAO: Oilseed Report PAK73/047.
(3) Experience, Incorporated: Feasibility Study on Cotton Seed Production, Marketing, Storage and Processing and Marketing of Cotton Seed Products, Phase I, II.

OTHER CONSIDERATIONS

Weather

Perhaps the most common subject relating to production decline in this study has been the concern with weather in the past several years. Information obtained from growers, extension personnel, research scientists and government officials place strong emphasis on the role of rainfall and humidity in production decline since 1973-74.[1] Rainfall following sowing has created soil crusting which leads to poor stands or resowing.

Heavy rains in July - September have been cited as causing excessive bud and flower shedding. While the rains do not cause flower shedding directly, they can and very likely do, cause indirect shedding. Prolonged periods of rainfall may result in excessive vegetative growth which is highly conducive to insect build-up and greatly increases the difficulty of their control. Insects can destroy small fruit forms rapidly. Naturally, more excessive vegetative growth follows fruit loss.

Water standing too long in a field leads to oxygen starvation of the roots. If rainfall is sufficient to pool water in a field for several days, plant growth slows, stops or even results in death. Fruit that was set on the plant may shed. Serious thought should be given to how methods can be devised to drain such heavy water accumulation from fields on a local basis. This might involve restructuring watercourses, selecting higher fields for cotton in order to drain to a lower fields and the use of ridge

(1) Figures 1 - 5, Appendix.

sowing. Ridges serve to get the plant on higher land and for some drainage effect. When flooding occurs, either from excessive rainfall or river overflow to the extent the cotton is destroyed, the acreage destroyed is not included in the production statistics. Two such years were 1973-74 and 1976-77 when large acreages were destroyed. In 1973, 655,000 acres, and in 1976, 300,000 acres were reported to have been destroyed.[1] While this statistical techniques does not affect the total bales of cotton reported to have been produced, it does give an unrealistic acre yield assessment.A line running roughly through Multan to the Indian border on the east, and to the desert on the west, and north through the cotton producing areas of the Punjab, is the region that has suffered the greatest decline. It is also the largest sector of cotton production in the country. The weather records show [2] that in the past 2 - 3 years most districts in this large area have received considerably more than long term average rainfall in July - September. One research objective should be to design dates of the planting (sowing) experiments to evaluate the performance of the range of maturity types of variety materials under the existing climatic conditions over a period of several years. The plant breeding aspects of such materials is discussed under the Plant Breeding Section.

Farm Size

The average size cotton farm is between two and three acres. Size tends

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(1) Source: verbal communication - Ministry of Agriculture officials.
(2) Figures 1 - 5, Appendix

to be larger in the Sind with about 10 - 12 acres per farm. Farm units of such size pose serious limitations on what the farmer can do. Generally, mechanization - particularly tractors - is not economically feasible. Credit is difficult to obtain, transport limitations and road conditions present problems in transporting fertilizers, chemicals and ohter materials from source to the farm and produce to the delivery points.

Literacy rates are low in the small farming situations and small farms make up a high percentage of the total. Extension activities are difficult under such conditions. Profitable insect control is most difficult under such conditions.

All of these factors have a strong bearing on imporving farming practices and making the desired impact on the improvement of efforts by the farmers.

Incentives

Motivation of people to do something differently than has been done traditionally is a difficult task and comes in many ways.

Everyone understands the incentive of money, especially as more income translated into improved living conditions, diet, clothing, schooling for children, social status and many other things.

While the 'progressive' farmers readily recognize the discrepancy between farm prices of cotton and world market prices, they are more concerned

with the spread between farm prices and domestic textile mill prices paid for the lint. There is little doubt that the 'progressive' farmers would put more economic resources into their farming if higher prices are available. It is not equally clear that the small farmer would do likewise. He might well be satisfied with the additional income that the higher price would give and not be motivated to put additional efforts into his farming practices.

Another incentive that has been largely ignored by the government policies is that of marketing systems. Until a realistic lint classification system is established and the farmer is rewarded (or penalized) for the quality of the cotton he produces, he will have little incentive to produce a better product. This subject is one that should be thoroughly investigated by competent marketing specialists.

Extension

All agriculturally oriented countries have experienced frustrating problems in trying to develop an effective extension program. The reasons are numerous. A good extension man has to have a like for people. He must also enjoy working with people and take satisfaction in seeing people make improvement. He must also have a deep feeling for the meaning of agriculture. The most successful extension people usually come from farm backgrounds. Obviously, there is a requirement of good agricultural training in preparation for the work.

Several extension directors appear to know their jobs and are working hard. Others are not so impressive. There seems to be a large extension personnel payroll in the country, but it is difficult to determine just how many are really concerned with actual extension work and how many are unnecessary "support" personnel.

One trained professional has from 12,000 to 18,000 acres assigned to him for his extension responsibility. By Western World standards this would appear to be a reasonable assignment. However, when it is realized that this involves from 5,000 to 7,000 individual farmers, them it is obvious that one person cannot do an adequate extension job on his assignment. Furthermore, the lack of adequate roads imposes a real obstacle in moving from place to place and this further limits effectiveness.

There is a pressing need for a more effective extension service in the country.

RECOMMENDATIONS

PRIORITY

1. Better Insect Control

Weather, particularly high rainfall, has a significant impact on insect popualtions and their control. Insects cannot be controlled on an automatic

(calendar) basis with or without good insecticide application machinery. Implementation of an effective insect control program requires an accurate insect population assessment prior to spray application. Application will only be done if assessment shows need. Assessment can only be accomplished by qualified entomological scouts. In order to have qualified scouts, in sufficient numbers, it will be necessary to organize and operate a Training Program. Scouts recommend proper insecticide, dosage, timing and method of application. Improved spraying machinery must be developed.

2. Improvement of Seed Quality

The consistently poor quality of sowing seed contributes to poor stands, weak plants and low yield. All possible speed must be made to get the newly established Seed Corporation into effective operation. Appropriate monitoring by highly competent seed specialists, of all phases of seed production from nucleus seed through distribution to farmers is required to guarantee the desired results.

3. Strengthen Cotton Breeding Programs

Implementation may require some changes in priorities of research objectives. However, there should be little additional in resource requirements. Emphasis should be placed on the objective of maximinzing yields through varietal development to better cope with varying climatic (weather) conditions expected during crop seasons. This objective should be further

strengthened by research on crop-climate interactions. The programs should be conducted only at major research locations.

4. Strongly Encourage Ridge and Line Sowing

Broadcast (flat) sowing is the absolutely poorest method of sowing cotton. The practice adversely affects stands (plant population), makes insect and weed control much more difficult, is wasteful of water and reduces yield. Line sowing is a considerable improvement over broadcast sowing and ridge sowing is greatly superior to both. Implementation will involve a difficult education (extension) program. Farmers can be taught that ridge and line sowing can be done with any source of power.

5. Establish a National Cotton Variety Testing Program

Program should include leading local varieties, several prominent exotic varieties and be conducted at representative locations (20-25) throughout the major cotton producing areas of the country. Varieties under test should be held constant for at least 3 years. Strain and variety testing programs and crop-climate research studies mentioned in priority 3 will strongly support this national program. Implementation can be effected with little added funding or personnel.

6. Improve Weed Control

The high incidence of weed populations in cotton fields is reducing yield

by competition with cotton. Implementation of an effective extension program strongly encouraging line and particularly ridge sowing, cultivation and hand weeding further into season than is now practiced, would improve yield and reduce future weed populations by reducing the number of weed seed produced by weed plants.

7. Improve Land Leveling

Few fields, regardless of size are adequately leveled. Therefore, water management is poor, stands are difficult to obtain and valuable water is wasted. Implementation will be utilizing engineering capabilities and improved farm leveling machinery. Time factor will probably be long due to shortage of both requirements. Ridge sowing would nullify some of the disadvantages of slightly unlevel land and improving water management. It would also alleviate, to some extent, the problem of excessive water on fields following heavy rains.

8. Improve Stands

This item has been mentioned in several of the priority listings above. It is emphasized here as poor stands (plant populations per acre) is one of the limiting factors of production. Uniformly spaced plant populations of 15,000 - 20,000 per acre are absolutely essential for attaining potential yield. Every conceivable effort must be made to obtain optimum stands in cotton farming.

IMPLEMENTATION

The cotton team is aware of the several studies that have been conducted on cotton production and research facilities, personnel and programs in the past several years. The leader of the team has made four of such studies, and the entomologist has made two. Most of the studies conducted by such organizations as Ford and Rockefeller Foundations, The World Bank, FAO, UNDP, USAID sponsored studies, and the British Cotton Corporation, have made highly relevant recommendations to improve Pakistan cotton production.

There has been progress over the past ten years. One example is the development of the Cotton Research Institutes at Multan and Sakrand.[1] This will give the country, for the first time, the capability of conducting research that will lead to better varieties, cultural practices, and, hopefully, insect control. Even though the Sakrand Station is just now under development, it should start operating in a relatively short time. If the programs there and at Multan are properly planned, keeping priority goals in mind, and executed with sound scientific approaches and integrity, significant contributions can and should be made to Pakistan agriculture.

This report will make recommendations that, if implemented, will have a strong positive effect on cotton production in the future. The team strongly urges that the implementation of these recommendations be started with all possible speed.

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(1) See Field Trip, pp. 1-5, Appendix

APPENDIX

FIELD TRIP

The day after the specialist in entomology and plant breeding arrived in Islamabad, the three-member team left on a tour of the principal cotton producing areas of Pakistan. We visited and conferred variously with government officials, experimental station and institute directors, scientists, technologists, extension specialists and farmers in Lahore, Lyallpur, Sahiwal, Multan, Hyderabad, Tando Jam and Karachi. We were joined, in Lahore, by the Director of the Cotton Research Institute, Multan, Pakistan counterpart member of the team. He traveled with us on most of the journey from Lahore to Karachi, The other counterpart member, the Director of Research, Pakistan Central Cotton Committee, conducted our trip to Hyderabad and Tando Jam. The trip from Lahore to Multan was by ground transport, and while we were, of course, unable to observe cotton growing in the field, we did get an overview of the agriculture and agricultural capabilities of the extensive irrigated area through which we traveled, and were able to get a concept of the inherent potential of the land in terms of the wheat and other growing crops.

Lahore

In Lahore we did not confer with a plant breeder (botanist). We did, however, have useful talks with officials of WAPDA; the Secretary of Agriculture, Punjab; the Director General of Agricultural Extension, Punab; and the officials of the newly organized Seed Corporation. The Director General expressed the opinion that the seed supplied to the growers has been of rather poor quality and on further inquiry by members of the team, he stated that the stocks were mixed or mongrelized with other types and kinds of cotton which he felt lowered the overall potential performance of the planting seed being released to the farmers.

Lyallpur

We met with the Director of the Punjab Agricultural Research Institute, at least two plant breeders (cotton botanists), agronomist and entomologist of the Institute staff. The Head of the Department of Plant Breeding, Punjab Agricultural University, who is doing some cotton breeding, also sat in on the discussions. In the main, the scientists expressed the feeling that the very low yields of recent years were caused, directly or indirectly, by adverse weather (mostly heavy rains at planting time and in July and August when the crop should be setting). We asked for tabular material or summary tables giving the yield or performance test data incuding, 1) the principal agricultural varieties recommended for the Division or Province and promising advanced strain, 2) yield data on these varieties and strains over a period of years (10 years or more if possible). and 3) yield data on these varieties and strains taken from tests conducted at several places in each of the several years. We also requested research results on agronomic and entomological studies. Some of the type data requested were eventually sent to us. We were also told that, within the Province, several ecological zones were recognized and attempts were being made to breed varieties for the various zones. The one entomologist at the station conducts research on all field crop insects. He only spends part time on cotton. The agronomist works primarily on wheat, but does some work on cotton.

Sahiwal

We were accompanied to this station by the cotton botanist in the Agricultural Experiment Station, Sahiwal. He is the technical member of the staff at the station. Our short visit to Sahiwal was spent in the office of the Agricultural Extension Officer where we talked with a group of farmers. These farmers were represented to us as being relatively large land holders who had managed to grow acceptable crops of cotton even in the recent adverse years. We gathered that these farmers had planted most, if not all, of their cotton to an early maturing, rapid fruiting American variety.

Multan

There are two plant breeding groups or units at Multan. One which reports administratively to the Agricultural Research Institute in Lyallpur has been conducting a plant breeding program for many years. The other, the Cotton Research Institute, was initially established for the purpose of conducting basic research in cotton and only recently has it been authorized to conduct research in plant breeding. It was apparent to the team, that strong cooperation had been established between the two units. As far as we were able to determine, the Cotton Research Institute has mounted and is prosecuting the most comprehensive program of cotton research in Pakistan. The total program contains research in plant breeding, cytology, physiology, soil science, agronomy, entomology, and pathology. We conferred with the Director and the principal scientist who work in the various scientific disciplines and with the plant breeder in the cooperating unit. We were supplied with experimental data and written reports which have contributed substantially to the rather broad appraisal of the role of plant breeding in the amelioration of some of the factors and imponderables inherent in the current low yield problem.

Agronomic work is underway on dates of planting experiments, line and ridge sowing, irrigation, fertilizer and trials, weed control and physiological growth and development studies.

The pathology section has determined that the principal disease problem is bacterial blight with minor problems with root rots and boll rots. The weed control work is quite new and little research has been done. A program on phosphorus nutrition is underway. This may be a questionable undertaking in light of lack of phosphorus response by cotton on alkaline soils in other desert areas of the world.

The agronomist is doing some experimental work on ridges. The new FAO agronomist is just getting a program underway.

Entomologists are carrying on an integrated research control program with major emphasis on the pink bollworm. They have an ample supply of the sex lure and are using it in survey and mating confusion experiments. One of the entomologists spent six months during 1976-77 in the United States visiting research laboratories and attended the Cotton Insect Research Conference. We believe the cotton insect research program is productive with the possible exception of field insecticide research. Greater emphasis would be placed on practical, applied research under natural conditions.

Hyderabad

We conferred with the Director of Extension - Sind, who pointed out that while yields of cotton in the Sind are relatively low and yields during the past two years have shown a slight decline, the magnitude of the reduction was relatively slight when compared with the losses sustained in the Punjab.

Tando Jam

The Agricultural Research Institute at Tando Jam is the Sind counterpart of the Punjab Agricultural Research Institute in Lyallpur. A plant breeding program is in progress. There are also programs in agronomy, entomology, soil science and pathology. In addition to the usual objective of developing higher yields, the program also includes an effort to develop better adaptation to the local climate, which generally is hot and dry. The one entomologist conducts research on all crops, including cotton. He is unable to contribute much towards solving cotton insect problems.

Sakrand

An institute similar to the one at Multan is under construction at Sakrand. We did not visit the site of the institute, but we did visit and travel with its Director who informed us that the institute was just being

established with a program similar to that in Multan.

Karachi

Because of circumstances beyond our control, our conference with the Director and other officials of the Pakistan Central Cotton Committee had to be cancelled. Pertinent data was posted by the PPC to Islamabad and is being used in the preparation of this report.

Table I —COTTON ACREAGE (Includes Desi)

Province/Division/ District	66-67	67-68	68-69	69-70	70-71	71-72	72-73	73-74	74-75	75-76	76-77*
1	2	3	4	5	6	7	8	9	10	11	12
					('000' acres)						
PAKISTAN ...	4,003	4,411	4,313	4,338	4,283	4,837	4,967	4,559	5,019	4,575	4,694
PUNJAB ...	2,963	3,289	3,232	3,322	3,233	3,697	3,901	3,383	3,822	3,420	3,397
Rawalpindi Division	57	57	49	42	28	30	30	28	31	29	27
Campbellpur ...	1	2	1	1	1	1	—	—	1	1	—
Rawalpindi ...	1	—	—	—	—	—	—	—	1	—	—
Jhelum ...	7	8	6	6	2	1	1	2	3	3	—
Gujrat ...	48	47	42	35	25	28	29	26	26	25	—
Lahore Division	177	201	170	181	150	179	188	161	161	172	159
Sialkot ...	26	24	19	22	15	14	14	11	15	13	—
Gujranwala ...	21	32	25	27	23	25	24	24	25	33	—
Sheikhupura ...	55	59	53	49	39	42	47	36	39	33	—
Lahore ...	75	86	73	83	73	98	103	90	82	93	—
Sargodha Division	655	738	692	694	653	735	765	526	696	581	544
Lyallpur ...	220	274	245	242	227	271	283	216	248	205	—
Sargodha ...	224	239	218	206	187	201	210	161	184	153	—
Jhang ...	196	208	216	229	226	246	246	126	226	188	—
Mianwali ...	15	17	13	17	13	17	26	23	38	35	—
Multan Division	1,465	1,588	1,600	1,688	1,749	1,937	2,031	1,958	2,026	1,831	1,816
Sahiwal ...	522	575	558	585	599	657	689	666	666	590	—
Multan ...	806	854	886	930	949	1,001	1,051	1,022	1054	981	—
Muzaffargarh ...	78	92	90	103	114	154	165	136	167	152	—
D. G. Khan ...	59	67	66	70	87	125	126	134	139	108	—
Bahawalpur Division	609	705	721	717	653	816	887	718	907	807	851
Bahawalpur ...	102	132	149	155	149	186	209	189	195	171	—
Bahawalnagar ...	175	212	229	212	169	237	267	273	275	269	—
Rahimyar Khan...	332	361	343	350	335	393	411	248	437	367	—

Continued

Continued

Province/Division/ District	66-67	67-68	68-69	69-70	70-71	71-72	72-73	73-74	74-75	75-76	76-77*
1	2	3	4	5	6	7	8	9	10	11	12
					('000' acres)						
SIND ...	**1,035**	**1,114**	**1,076**	**1,010**	**1,045**	**1,135**	**1,060**	**1,167**	**1,189**	**1,149**	**1,288**
Khairpur Division	**298**	**332**	**335**	**332**	**321**	**408**	**371**	**378**	**457**	**447**	**532**
Khairpur ...	78	78	92	95	97	110	104	103	105	110	—
Jacobabad ...	3	16	9	3	4	5	5	4	3	4	—
Sukkur ...	58	76	62	86	66	111	86	93	170	157	—
Nawabshah ...	159	162	172	148	153	181	175	178	178	174	—
Larkana ...	—	—	—	—	1	1	1	—	1	2	—
Hyderabad Division	**737**	**782**	**741**	**678**	**724**	**727**	**689**	**789**	**732**	**702**	**756**
Hyderabad ...	217	248	225	211	228	228	211	230	213	201	—
Tharparkar ...	280	289	274	243	254	251	235	286	256	241	—
Sanghar ...	237	241	239	220	240	246	239	264	251	255	—
Dadu ...	3	4	3	3	2	2	3	8	10	4	—
Thatta ...	—	—	—	1	1	—	—	1	2	1	—
N.W.F.P. ...	**5**	**8**	**5**	**6**	**5**	**5**	**6**	**8**	**7**	**6**	**7**
Peshawar Division	**3**	**4**	**3**	**4**	**2**	**2**	**2**	**4**	**2**	**2**	**2**
Peshawar ...	3	4	3	3	2	2	2	3	2	2	—
Mardan ...	—	—	—	—	—	—	—	—	—	—	—
Hazara ...	—	—	—	—	—	—	—	1	—	—	—
D. I. Khan Division	**2**	**4**	**2**	**2**	**3**	**3**	**4**	**4**	**5**	**4**	**5**
Bannu ...	1	1	1	1	1	1	1	1	1	1	—
D. I. Khan ...	1	3	1	1	2	2	3	3	4	3	—
BALUCHISTAN	—	—	—	—	—	—	—	1	1	b	2
Quetta Division	—	—	—	—	—	—	—	—	—	—	—
Quetta ...	—	—	—	—	—	—	—	—	—	—	—
Loralai ...	—	—	—	—	—	—	—	—	—	—	—
Kalat Division	—	—	—	—	—	—	—	1	1	—	2
Kacchi	—	—	—	—	—	—	—	1	1	—	—
Kalat	—	—	—	—	—	—	—	—	—	—	—
Mekran	—	—	—	—	—	—	—	—	—	—	—
Lasbella	—	—	—	—	—	—	—	—	—	—	—

Source :—Ministry of Agriculture. Government of Pakistan.

N.B.—Break-up may not add upto total due to rounding off.

b=Below one thousand.

*First Estimate

Table 2 —UPLAND COTTON ACREAGE

Province/Division/ District	66-67	67-68	68-69	69-70	70-71	71-72	72-73	73-74	74-75	75-76	76-77*
1	2	3	4	5	6	7	8	9	10	11	12
					('000' acres)						
PAKISTAN	3,550	3,886	3,828	3,934	3,980	4,442	4,569	4,200	4,657	4,192	4,336
PUNJAB ...	2,681	2,939	2,911	3,024	3,017	3,426	3,609	3,126	3,582	3,147	3,117
Rawalpindi Division	41	40	35	28	18	21	22	20	20	18	16
Campbellpur ...	—	—	—	—	—	—	—	—	—	—	—
Rawalpindi ...	—	—	—	—	—	—	—	—	—	—	—
Jhelum ...	—	—	—	1	—	—	—	—	1	—	—
Gujrat ...	41	40	35	27	18	21	22	20	19	18	—
Lahore Division	78	83	67	65	60	77	67	62	60	57	51
Sialkot ...	—	—	—	—	—	—	—	—	1	—	—
Gujranwala ...	15	17	12	13	11	15	14	14	13	17	—
Sheikhupura ...	49	54	47	42	34	38	40	32	32	24	—
Lahore ...	14	12	8	10	15	24	13	16	14	16	—
Sargodha Division	629	700	660	657	624	701	735	503	658	539	506
Lyallpur ...	210	254	226	221	210	251	267	205	232	180	—
Sargodha ...	216	229	211	199	181	195	205	157	178	149	—
Jhang ...	194	207	215	228	226	244	244	125	224	187	—
Mianwali ...	9	10	8	9	7	11	19	16	24	23	—
Multan Division	1,446	1,558	1,576	1,665	1,727	1,913	2,006	1,938	2,005	1,807	1,785
Sahiwal ...	519	562	547	576	589	646	678	659	658	576	—
Multan ...	797	846	879	924	942	995	1,046	1,018	1,049	976	—
Muzaffargarh ...	73	87	85	99	110	148	158	129	161	148	—
D. G. Khan ...	57	63	65	66	86	124	124	132	137	107	—
Bahawalpur Division	487	558	573	609	588	714	779	603	838	726	759
Bahawalpur ...	87	110	130	144	143	175	198	181	189	166	—
Bahawalnagar ...	70	89	101	116	113	148	172	175	214	195	—
Rahimyar khan ...	330	359	342	349	332	391	409	247	435	365	—

Continued

Continued

Province/Division/ District	66-67	67-68	68-69	69-70	70-71	71-72	72-73	73-74	74-75	75-76	76-77*
1	2	3	4	5	6	7	8	9	10	11	12
					('000' acres)						
SIND ...	869	947	917	910	963	1,016	960	1,074	1,075	1,046	1,219
Khairpur Division	175	211	198	232	239	289	271	285	352	343	463
Khairpur ...	61	57	63	63	77	84	81	84	84	82	—
Jacobabad ...	2	13	5	3	4	5	5	4	2	4	—
Sukkur ...	34	43	35	86	66	111	86	93	170	157	—
Nawabshah ...	78	98	95	80	91	88	98	104	96	98	—
Larkana ...	—	—	—	—	1	1	1	—	—	2	—
Hyderabad Division	694	736	719	678	724	727	689	789	723	702	756
Hyderabad ...	201	223	218	211	228	228	211	230	210	201	—
Tharparkar ...	262	273	265	243	254	251	236	286	256	241	—
Sanghar ...	230	238	235	220	240	246	239	264	251	255	—
Dadu ...	1	2	1	3	2	2	3	8	6	4	—
Thatta ...	—	—	—	1	—	—	—	1	—	1	—
N.W.F.P. ...	—	—	—	—	—	—	—	—	—	—	—
Peshawar Division	—	—	—	—	—	—	—	—	—	—	—
Peshawar ...	—	—	—	—	—	—	—	—	—	—	—
Mardan ...	—	—	—	—	—	—	—	—	—	—	—
Hazara ...	—	—	—	—	—	—	—	—	—	—	—
D. I. Khan Division	—	—	—	—	—	—	—	—	—	—	—
Bannu ...	—	—	—	—	—	—	—	—	—	—	—
D. I. Khan ...	—	—	—	—	—	—	—	—	—	—	—
BALUCHISTAN	—	—	—	—	—	—	—	—	—	—	—
Quetta Division	—	—	—	—	—	—	—	—	—	—	—
Quetta ...	—	—	—	—	—	—	—	—	—	—	—
Loralai ...	—	—	—	—	—	—	—	—	—	—	—
Kalat Division	—	—	—	—	—	—	—	—	—	—	—
Kacchi ...	—	—	—	—	—	—	—	—	—	—	—
Kalat ...	—	—	—	—	—	—	—	—	—	—	—
Mekran ...	—	—	—	—	—	—	—	—	—	—	—
Lasbella ...	—	—	—	—	—	—	—	—	—	—	—

Source :— Ministry of Agriculture, Government of Pakistan.
N.B.—Break-up may not add upto total due to rounding off.
*First Estimate

Table 3 —COTTON PRODUCTION (Includes Desi)

Province/Division/ District	66-67	67-68	68-69	69-70	70-71	71-72	72-73	73-74	74-75	75-76	76-77
1	2	3	4	5	6	7	8	9	10	11	12
					('000' bales)						
PAKISTAN ...	2,606	2,911	2,967	3,012	3,051	3,979	3,947	3,704	3,567	2,889	N.A.
PUNJAB ...	1,898	2,165	2,174	2,244	2,229	2,976	2,826	2,525	2,476	1,937	—
Rawalpindi Division	26	26	18	18	14	16	16	15	14	11	—
Campbellpur ...	—	—	—	—	—	—	—	—	—	—	—
Rawalpindi ...	—	—	—	—	—	—	—	—	—	—	—
Jhelum ...	2	2	2	1	1	—	—	1	1	1	—
Gujrat ...	24	24	16	17	13	16	16	14	13	10	—
Lahore Division	71	85	74	74	65	89	71	70	65	75	—
Sialkot ..	7	8	9	7	5	5	5	4	5	4	—
Gujranwala ...	9	14	13	11	9	12	10	11	10	11	—
Sheikhupura ...	26	32	26	23	20	24	21	16	16	15	—
Lahore ...	29	31	26	33	31	48	35	39	34	44	—
Sargodha Division	374	430	325	357	363	484	448	314	364	271	—
Lyallpur ...	144	176	108	137	136	196	191	146	143	109	—
Sargodha ...	137	147	104	106	103	132	120	92	99	73	—
Jhang ...	88	101	109	108	118	148	127	66	108	77	—
Mianwali ...	5	6	4	6	6	8	10	10	14	12	—
Multan Division	1,130	1,215	1,334	1,335	1,383	1,797	1,704	1,668	1,487	1,154	—
Sahiwal ...	419	456	350	508	521	677	609	599	445	334	—
Multan ...	645	683	899	746	760	958	938	918	879	699	—
Muzaffargarh ...	38	44	42	53	63	95	93	79	94	73	—
D. G. Khan ...	28	32	43	28	39	67	64	72	69	48	—
Bahawalpur Division	297	409	423	469	404	590	587	458	545	426	—
Bahawalpur ...	41	62	78	90	37	128	127	116	111	87	—
Bahawalnagar ...	70	120	75	109	94	148	155	163	161	144	—
Rahimyar Khan...	186	227	270	261	223	314	305	179	273	195	—

Continued

Continued

Province/Division/ District	66-67	67-68	68-69	69-70	70-71	71-72	72-73	73-74	74-75	75-76	76-77
1	2	3	4	5	6	7	8	9	10	11	12
					('000' bales)						
SIND ...	706	742	790	766	820	1,000	1,118	1,175	1,087	949	—
Khairpur Division	174	191	180	190	219	346	356	313	367	248	—
Khairpur ...	50	50	50	49	64	94	100	93	84	91	—
Jacobabad ...	1	8	4	1	2	2	3	3	2	4	—
Sukkur ...	26	34	28	47	44	103	88	85	143	132	—
Nawabshah ...	97	99	98	93	109	147	164	132	138	120	—
Larkana ...	—	—	—	—	—	—	—	1	—	1	—
Hyderabad Division	532	551	610	576	601	654	762	862	720	601	—
Hyderabad ...	161	176	167	176	185	212	229	222	215	196	—
Tharparkar ...	191	197	203	211	225	232	278	330	251	168	—
Sanghar ...	180	176	239	188	190	209	259	305	246	232	—
Dadu ...	—	2	1	1	1	1	1	5	7	4	—
Thatta ...	—	—	—	—	—	—	—	—	1	1	—
N.W.F.P. ...	2	4	3	2	2	2	3	4	3	3	—
Peshawar Division	1	2	2	1	1	1	1	2	1	1	—
Peshawar ...	1	2	2	1	1	1	1	2	1	1	—
Mardan ...	—	—	—	—	—	—	—	—	—	—	—
Hazara ...	—	—	—	—	—	—	—	—	—	—	—
D. I. Khan Division	1	2	1	1	1	1	2	2	2	2	—
Bannu ...	—	1	—	—	—	—	—	1	—	—	—
D. I. Khan ...	1	1	1	1	1	1	2	1	2	2	—
BALUCHISTAN	—	—	—	—	—	—	—	b	b	b	—
Quetta Division	—	—	—	—	—	—	—	—	—	—	—
Quetta ...	—	—	—	—	—	—	—	—	—	—	—
Loralai ...	—	—	—	—	—	—	—	—	—	—	—
Kalat Division ...	—	—	—	—	—	—	—	—	—	—	—
Kacchi ...	—	—	—	—	—	—	—	—	—	—	—
Kalat ...	—	—	—	—	—	—	—	—	—	—	—
Mekran ...	—	—	—	—	—	—	—	—	—	—	—
Lasbella ...	—	—	—	—	—	—	—	—	—	—	—

Source :— Ministry of Agriculture, Government of Pakistan.
N.B.—Break-up may not add upto total due to rounding off.
b—Below one thousand.

Table 4 —UPLAND COTTON PRODUCTION

Province/Division/ District	66-67	67-68	68-69	69-70	70-71	71-72	72-73	73-74	74-75	75-76	76-77
1	2	3	4	5	6	7	8	9	10	11	12
					('000' bales)						
PAKISTAN	2,434	2,702	2,788	2,847	2,912	3,774	3,746	3,529	3,392	2,716	N.A.
PUNJAB ...	1,800	2,032	2,063	2,126	2,136	2,852	2,712	2,414	2,383	1,834	—
Rawalpindi Division	21	21	13	14	10	13	13	12	11	9	—
Campbellpur ...	—	—	—	—	—	—	—	—	—	—	—
Rawalpindi ...	—	—	—	—	—	—	—	—	—	—	—
Jhelum ...	—	—	—	—	—	—	—	—	—	—	—
Gujrat ...	21	21	13	14	10	13	13	12	11	9	—
Lahore Division	38	44	34	31	30	44	32	31	28	29	—
Sialkot ...	—	—	—	—	—	—	—	—	—	—	—
Gujranwala ...	7	8	7	6	5	8	7	7	6	7	—
Sheikhupura ...	24	30	23	20	18	22	18	15	14	12	—
Lahore ...	7	6	4	5	7	14	7	9	8	10	—
Sargodha Division	366	416	312	343	351	469	436	305	351	258	—
Lyallpur ...	140	167	100	127	129	187	184	142	137	101	—
Sargodha ...	134	144	100	104	101	129	118	90	96	71	—
Jhang ...	88	101	109	108	118	147	126	65	107	77	—
Mianwali ...	4	4	3	4	3	6	8	8	11	9	—
Multan Division	1,122	1,205	1,324	1,326	1,372	1,786	1,694	1,660	1,479	1,146	—
Sahiwal ...	418	452	345	504	515	671	604	596	441	329	—
Multan ...	641	680	896	743	757	955	936	917	877	697	—
Muzaffargarh ...	36	42	40	52	61	93	90	76	92	72	—
D. G. Khan ...	27	31	43	27	39	67	64	71	69	48	—
Bahawalpur Division	253	346	380	412	373	540	537	406	514	392	—
Bahawalpur ...	36	54	72	86	85	123	122	112	110	86	—
Bahawalnagar ...	32	66	39	65	67	104	111	115	132	112	—
Rahimyar khan .	185	226	269	261	221	313	304	179	272	194	—

Continued

Continued

Province/Division/ District	66-67	67-68	68-69	69-70	70-71	71-72	72-73	73-74	74-75	75-76	76-77
1	2	3	4	5	6	7	8	9	10	11	12
				('000' bales)							
SIND ...	**634**	**670**	**725**	**721**	**776**	**922**	**1,034**	**1,106**	**1,009**	**882**	**N.A.**
Khairpur Division	**118**	**139**	**125**	**145**	**175**	**268**	**272**	**244**	**295**	**281**	—
Khairpur ...	42	40	39	39	57	78	81	76	70	72	—
Jacobabad ...	1	7	3	1	2	2	3	3	1	4	—
Sukkur ...	15	20	17	47	44	103	88	85	143	132	—
Nawabshah ..	60	72	66	58	72	85	99	80	81	72	—
Larkana ...	—	—	—	—	—	—	—	—	—	1	—
Hyderabad Division	**516**	**531**	**600**	**576**	**601**	**654**	**762**	**862**	**714**	**601**	—
Hyderabad ...	156	164	164	176	185	212	229	222	212	196	—
Tharparkar ...	183	191	199	211	225	232	273	330	251	168	—
Sanghar ...	177	175	237	188	190	209	259	305	246	232	—
Dadu ...	—	1	—	1	1	1	1	5	5	4	—
Thatta ...	—	—	—	—	—	—	—	—	—	1	—
N.W.F.P.	—	—	—	—	—	—	—	—	—	—	—
Peshawar Division	—	—	—	—	—	—	—	—	—	—	—
Peshawar ...	—	—	—	—	—	—	—	—	—	—	—
Mardan ...	—	—	—	—	—	—	—	—	—	—	—
Hazara ...	—	—	—	—	—	—	—	—	—	—	—
D. I. Khan Division	—	—	—	—	—	—	—	—	—	—	—
Bannu ...	—	—	—	—	—	—	—	—	—	—	—
D. I. Khan ...	—	—	—	—	—	—	—	—	—	—	—
BALUCHISTAN	—	—	—	—	—	—	—	—	—	—	—
Quetta Division	—	—	—	—	—	—	—	—	—	—	—
Quetta ...	—	—	—	—	—	—	—	—	—	—	—
Loralai ...	—	—	—	—	—	—	—	—	—	—	—
Kalat Division	—	—	—	—	—	—	—	—	—	—	—
Kacchi ...	—	—	—	—	—	—	—	—	—	—	—
Kalat ...	—	—	—	—	—	—	—	—	—	—	—
Mekran ...	—	—	—	—	—	—	—	—	—	—	—
Lasbella ...	—	—	—	—	—	—	—	—	—	—	—

Source :— Ministry of Agriculture, Government of Pakistan.
N.B.—Break-up may not add upto total due to rounding off.

Table 5 –COTTON YIELD (Includes Desi)

Province/Division/ District	66-67	67-68	68-69	69-70	70-71	71-72	72-73	73-74	74-75	75-76	76-77
1	2	3	4	5	6	7	8	9	10	11	12
					(Lbs. per acre)						
PAKISTAN	255	259	270	272	279	322	312	318	279	248	N.A.
PUNJAB ...	251	257	264	265	270	315	284	292	254	222	—
Rawalpindi Division	179	179	147	168	196	214	209	215	176	151	—
Campbellpur ...	—	—	—	—	—	—	—	—	132	—	—
Rawalpindi ...	—	—	—	—	—	—	—	—	99	—	—
Jhelum ...	131	112	105	131	196	—	—	209	123	86	—
Gujrat ...	196	200	153	181	204	230	216	216	189	163	—
Lahore Division	157	166	169	164	170	194	147	170	159	170	—
Sialkot ...	105	131	175	124	131	140	140	137	132	118	—
Gujranwala ...	168	171	199	164	153	182	170	176	156	130	—
Sheikhupura ...	185	212	196	185	201	229	172	178	156	179	—
Lahore ...	152	141	137	155	167	190	132	169	165	188	—
Sargodha Division	224	229	184	208	218	258	230	234	206	183	—
Lyallpur ...	257	252	172	222	235	283	265	265	222	210	—
Sargodha ...	240	241	186	202	216	258	225	224	214	187	—
Jhang ...	178	191	199	184	205	256	201	203	189	160	—
Mianwali ...	131	138	130	144	181	177	158	175	148	131	—
Multan Division	302	320	327	310	310	364	329	334	288	247	—
Sahiwal ...	315	311	246	340	341	404	346	353	263	222	—
Multan ...	314	314	397	318	314	375	350	352	329	279	—
Muzaffargrah ...	191	187	183	202	217	242	220	227	222	189	—
D. G. Khan ...	186	187	259	165	178	211	201	209	198	173	—
Bahawalpur Division	191	227	230	252	243	283	259	253	235	207	—
Bahawalpur ...	158	184	205	226	229	270	239	240	222	200	—
Bahawalnagar ...	157	222	128	201	218	245	227	234	230	210	—
Rahimyar Khan...	220	247	308	299	261	313	291	283	247	208	—

Continued

Continued

Province/Division/ District	66-67	67-68	68-69	69-70	70-71	71-72	72-73	73-74	74-75	75-76	76-77
1	2	3	4	5	6	7	8	9	10	11	12
					(Lbs. per acre)						
SIND ...	267	261	288	297	308	345	414	394	358	324	N.A.
Khairpur Division	229	225	210	224	267	333	376	324	315	305	—
Khairpur ...	251	251	210	201	260	336	377	354	312	325	—
Jacobabad ...	196	196	174	126	125	139	275	275	263	327	—
Sukkur ...	176	175	179	214	257	365	397	356	329	329	—
Nawabshah ...	239	240	224	246	281	317	368	290	304	270	—
Larkana ...	—	—	—	—	—	—	305	235	280	340	—
Hyderabad Division	283	276	323	333	326	353	433	428	387	336	—
Hyderabad ...	291	278	291	327	318	363	425	377	395	384	—
Tharparkar ...	267	267	291	340	347	363	453	452	387	274	—
Sanghar ...	298	286	392	334	311	333	425	452	387	357	—
Dadu ...	—	196	209	175	230	186	226	273	263	322	—
Thatta ...	—	—	—	—	—	—	—	235	263	353	—
N.W.F.P. ...	157	196	196	166	157	171	179	186	181	180	—
Peshawar Division	131	196	196	163	196	165	179	180	189	178	—
Peshawar ...	131	196	196	163	196	171	166	178	198	176	—
Mardan ...	—	—	—	—	—	—	196	196	198	392	—
Hazara ...	—	—	—	—	—	—	—	196	—	—	—
D. I. Khan Division	196	196	196	178	131	176	179	191	181	182	—
Bannu ...	—	392	—	—	—	196	224	211	140	147	—
D. I. Khan ...	196	131	178	178	131	170	172	182	198	190	—
BALUCHISTAN	—	—	—	—	—	—	—	294	173	261	—
Quetta Division	—	—	—	—	—	—	—	—	—	—	—
Quetta ...	—	—	—	—	—	—	—	—	—	—	—
Loralai ...	—	—	—	—	—	—	—	—	—	—	—
Kalat Division	—	—	—	—	—	—	—	261	173	—	—
Kacchi ...	—	—	—	—	—	—	—	261	198	—	—
Kalat ...	—	—	—	—	—	—	—	—	—	—	—
Mekran ...	—	—	—	—	—	—	—	—	132	—	—
Lasbella ...	—	—	—	—	—	—	—	—	—	198	—

Source :—Ministry of Agriculture, Government of Pakistan.

Table 6 —UPLAND COTTON YIELD

Province/Division/ District	66-67	67-68	68-69	69-70	70-71	71-72	72-73	73-74	74-75	75-76	76-77
1	2	3	4	5	6	7	8	9	10	11	12
					(Lbs. per acre)						
PAKISTAN	269	273	285	284	287	333	321	328	288	254	N.A.
PUNJAB ...	263	271	278	280	278	325	294	264	261	228	—
Rawalpindi Division	206	206	149	200	218	250	232	231	214	192	—
Campbellpur ...	—	—	—	—	—	—	—	—	—	—	—
Rawalpindi ...	—	—	—	—	—	—	—	—	—	—	—
Jhelum ...	—	—	—	—	—	—	—	—	—	143	—
Gujrat ...	206	206	149	200	218	250	232	231	222	192	—
Lahore Division	191	208	195	188	196	222	184	197	181	196	—
Sialkot ...	—	—	—	—	—	—	—	—	148	—	—
Gujranwala ...	183	185	222	182	178	199	193	206	172	149	—
Sheikhupura ...	192	218	192	191	207	232	178	184	165	191	—
Lahore ...	196	196	176	188	183	222	193	214	226	255	—
Sargodha Division	228	233	185	205	221	262	233	237	209	188	—
Lyallpur ...	261	258	173	226	241	292	271	271	232	221	—
Sargodha ...	243	247	185	205	219	260	226	226	211	187	—
Jhang ...	178	191	199	185	205	237	202	204	189	160	—
Mianwali ...	174	157	147	166	168	199	169	190	173	154	—
Multan Division	304	303	329	312	311	366	331	336	288	249	—
Sahiwal ...	316	315	247	343	343	407	349	354	263	224	—
Multan ...	315	315	399	319	315	376	351	352	329	278	—
Muzaffargarh ...	193	189	186	205	217	246	223	231	222	191	—
D. G. Khan ...	186	193	262	163	178	212	201	210	198	174	—
Bahawalpur Division	204	243	260	265	249	296	264	264	241	212	—
Bahawalpur ...	162	192	216	233	233	276	242	243	230	205	—
Bahawalnagar ...	179	291	150	220	232	275	252	258	239	225	—
Rahimyar Khan...	220	247	309	294	261	313	292	284	247	208	—

Continued

Continued

Province/Division/ District	66-67	67-68	68-69	69-70	70-71	71-72	72-73	73-74	74-75	75-76	76-77
1	2	3	4	5	6	7	8	9	10	11	12
					(Lbs. per acre)						
SIND ...	286	277	310	331	318	356	422	404	368	331	N.A.
Khairpur Division	264	258	247	245	287	364	393	335	329	321	—
Khairpur ...	270	275	240	240	291	363	390	357	329	342	—
Jacobabad ...	196	211	212	126	125	139	275	275	263	327	—
Sukkur ...	173	182	191	214	257	365	397	356	329	329	—
Nawabshah ...	301	288	274	288	313	377	397	302	329	288	—
Larkana ...	—	—	—	—	—	—	305	235	392	340	—
Hyderabad Division	291	283	327	333	336	353	433	428	387	331	—
Hyderabad ...	304	288	295	327	318	363	425	377	398	384	—
Tharparkar ...	274	274	295	340	347	363	453	452	387	274	—
Sanghar ...	302	288	396	334	311	333	425	452	387	357	—
Dadu ...	196	196	196	175	230	186	226	273	271	322	—
Thatta ...	—	—	—	—	—	—	—	235	—	353	—
N.W.F.P.	—	—	—	—	—	—	—	—	—	—	—
Peshawar Division	—	—	—	—	—	—	—	—	—	—	—
Peshawar ...	—	—	—	—	—	—	—	—	—	—	—
Mardan ...	—	—	—	—	—	—	—	—	—	—	—
Hazara ...	—	—	—	—	—	—	—	—	—	—	—
D. I. Khan Division	—	—	—	—	—	—	—	—	—	—	—
Bannu ...	—	—	—	—	—	—	—	—	—	—	—
D. I. Khan ...	—	—	—	—	—	—	—	—	—	—	—
BALUCHISTAN	—	—	—	—	—	—	—	—	—	—	—
Quetta Division	—	—	—	—	—	—	—	—	—	—	—
Quetta ...	—	—	—	—	—	—	—	—	—	—	—
Loralai ...	—	—	—	—	—	—	—	—	—	—	—
Kalat Division	—	—	—	—	—	—	—	—	—	—	—
Kacchi ...	—	—	—	—	—	—	—	—	—	—	—
Kalat ...	—	—	—	—	—	—	—	—	—	—	—
Mekran ...	—	—	—	—	—	—	—	—	—	—	—
Lasbella ...	—	—	—	—	—	—	—	—	—	—	—

Source :— Ministry of Agriculture, Government of Pakistan.

Table 7—DESI COTTON ACREAGE

Province/Division/ District	66-67	67-68	68-69	69-70	70-71	71-72	72-73	73-74	74-75	75-76	76-77*
1	2	3	4	5	6	7	8	9	10	11	12
					('000' acres)						
PAKISTAN	453	525	485	404	303	395	398	359	362	383	349
PUNJAB ...	282	350	321	298	216	271	292	257	240	273	280
Rawalpindi Division	16	17	14	14	10	9	8	8	11	11	11
Campbellpur ...	1	2	1	1	1	1	—	—	1	1	—
Rawalpindi ...	1	—	—	—	—	—	—	—	1	—	—
Jhelum ...	7	8	6	5	2	1	1	2	2	3	—
Gujrat ...	7	7	7	8	7	7	7	6	7	7	—
Lahore Division	99	118	103	116	90	102	121	99	101	115	108
Sialkot ...	26	24	19	22	15	14	14	11	14	13	—
Gujranwala ...	6	15	13	14	12	10	10	10	12	16	—
Sheikhupura ...	6	5	6	7	5	4	7	4	7	9	—
Lahore ...	61	74	65	73	58	74	90	74	68	77	—
Sargodha Division	26	38	32	37	29	34	30	23	38	42	38
Lyallpur ...	10	20	19	21	17	20	16	11	16	25	—
Sargodha ...	8	10	7	7	6	6	5	4	6	4	—
Jhang ...	2	1	1	1	—	2	2	1	2	1	—
Mianwali ...	6	7	5	8	6	6	7	7	14	12	—
Multan Division	19	30	24	23	22	24	25	20	21	24	31
Sahiwal ...	3	13	11	9	10	11	11	7	8	14	—
Multan ...	9	8	7	6	7	6	5	4	5	5	—
Muzaffargarh ...	5	5	5	4	4	6	7	7	6	4	—
D. G. Khan ...	2	4	1	4	1	1	2	2	2	1	—
Bahawalpur Division	122	147	146	108	65	102	108	107	69	81	92
Bahawalpur ...	15	22	19	11	6	11	11	8	6	5	—
Bahawalnagar ...	105	123	128	96	56	89	95	98	61	74	—
Rahimyar Khan...	2	2	1	1	3	2	2	1	2	2	—

Continued

Continued

Province/Division/ District	66-67	67-68	68-69	69-70	70-71	71-72	72-73	73-74	74-75	75-76	76-77*
1	2	3	4	5	6	7	8	9	10	11	12
					('000' acres)						
SIND ...	**166**	**167**	**159**	**100**	**82**	**119**	**100**	**93**	**114**	**104**	**69**
Khairpur Division	123	121	137	100	82	119	100	93	105	104	69
Khairpur ...	17	21	29	32	20	26	23	19	21	28	—
Jacobabad ...	1	3	4	—	—	—	—	—	1	—	—
Sukkur ...	24	33	27	—	—	—	—	—	—	—	—
Nawabshah ...	81	64	77	68	62	93	77	74	82	76	—
Larkana ...	—	—	—	—	—	—	—	—	1	—	—
Hyderabad Division	43	46	22	—	—	—	—	—	9	—	—
Hyderabad ...	16	25	7	—	—	—	—	—	3	—	—
Tharparkar ...	18	16	9	—	—	—	—	—	—	—	—
Sanghar ...	7	3	4	—	—	—	—	—	—	—	—
Dadu ...	2	2	2	—	—	—	—	—	4	—	—
Thatta ...	—	—	—	—	—	—	—	—	2	—	—
N.W.F.P. ...	**5**	**8**	**5**	**6**	**5**	**5**	**6**	**8**	**7**	**6**	**7**
Peshawar Division	3	4	3	4	2	2	2	4	2	2	2
Peshawar ...	3	4	3	3	2	2	2	3	2	2	—
Mardan ...	—	—	—	1	—	—	—	—	—	—	—
Hazara ...	—	—	—	—	—	—	—	1	—	—	—
D. I. Khan Division	2	4	2	2	3	3	4	4	5	4	5
Bannu ...	1	1	1	1	1	1	1	1	1	1	—
D. I. Khan ...	1	3	1	1	2	2	3	3	4	3	—
BALUCHISTAN	—	—	—	—	—	—	—	1	1	b	2
Quetta Division	—	—	—	—	—	—	—	—	—	—	—
Quetta ...	—	—	—	—	—	—	—	—	—	—	—
Loralai ...	—	—	—	—	—	—	—	—	—	—	—
Kalat Division	—	—	—	—	—	—	—	1	1	—	—
Kacchi ...	—	—	—	—	—	—	—	1	1	—	—
Kalat ...	—	—	—	—	—	—	—	—	—	—	—
Mekran ...	—	—	—	—	—	—	—	—	—	—	—
Lasbella ...	—	—	—	—	—	—	—	—	—	—	—

Source:—Ministry of Agriculture, Government of Pakistan,
N.B.—Break-up may not add upto total due to rounding off.
b=Below one thousand.
*First Estimate.

Table 8 -DESI COTTON PRODUCTION

Province/Division/ District	66-67	67-68	68-69	69-70	70-71	71-72	72-73	73-74	74-75	75-76	76-77
1	2	3	4	5	6	7	8	9	10	11	12
						('000' bales)					
PAKISTAN	172	209	179	165	139	205	201	184	175	173	N.A.
PUNJAB ...	98	133	111	118	93	124	114	111	92	103	—
Rawalpindi Division	5	5	5	4	4	3	3	3	3	2	—
Campbellpur ...	—	—	—	—	—	—	—	—	—	—	—
Rawalpindi ...	—	—	—	—	—	—	—	—	—	—	—
Jhelum ...	2	2	2	1	1	—	—	1	1	1	—
Gujrat ...	3	3	3	3	3	3	3	2	2	1	—
Lahore Division	33	41	40	43	35	45	39	39	37	46	—
Sialkot ...	7	8	9	7	5	5	5	4	5	4	—
Gujranwala ...	2	6	6	5	4	4	3	4	4	5	—
Sheikhupura ...	2	2	3	3	2	2	3	1	2	3	—
Lahore ...	22	25	22	28	24	34	28	30	26	34	—
Sargodha Division	8	14	13	14	12	15	12	9	13	13	—
Lyallpur ...	4	9	8	10	7	9	7	4	6	8	—
Sargodha ...	3	3	4	2	2	3	2	2	3	2	—
Jhang ...	—	—	—	—	—	1	1	1	1	b	—
Mianwali ...	1	2	1	2	3	2	2	2	3	3	—
Multan Division	8	10	10	9	11	11	10	8	8	8	—
Sahiwal ...	1	4	5	4	6	6	5	3	3	5	—
Multan ...	4	3	3	3	3	3	2	1	2	2	—
Muzaffargarh ...	2	2	2	1	2	2	3	3	2	1	—
D. G. Khan ...	1	1	—	1	—	—	—	1	1	—	—
Bahawalpur Division	44	63	43	48	31	50	50	52	31	34	—
Bahawalpur ...	5	8	6	4	2	5	5	4	1	1	—
Bahawalnagar ...	38	54	36	44	27	44	44	48	29	32	—
Rahimyar Khan...	1	1	1	—	2	1	1	—	1	1	—

Continued

Continued

Province/Division/ District	66-67	67-68	68-69	69-70	70-71	71-72	72-73	73-74	74-75	75-76	76-77
1	2	3	4	5	6	7	8	9	10	11	12
					('000' bales)						
SIND ...	72	72	65	45	44	78	84	69	79	67	N.A.
Khairpur Division	56	52	55	45	44	78	84	69	72	67	—
Khairpur ...	8	10	11	10	7	16	19	17	14	19	—
Jacobabad ...	—	1	1	—	—	—	—	—	1	—	—
Sukkur ...	11	14	11	—	—	—	—	—	—	—	—
Nawabshah ...	37	27	32	35	37	62	65	52	57	48	—
Larkana ...	—	—	—	—	—	—	—	—	—	—	—
Hyderabad Division	16	20	10	—	—	—	—	—	7	—	—
Hyderabad ...	5	12	3	—	—	—	—	—	3	—	—
Tharparkar ...	8	6	4	—	—	—	—	—	—	—	—
Sanghar ...	3	1	2	—	—	—	—	—	—	—	—
Dadu ...	—	1	1	—	—	—	—	—	2	—	—
Thatta ...	—	—	—	—	—	—	—	—	1	—	—
N.W.F.P. ...	2	4	3	2	2	2	3	4	3	3	—
Peshawar Division	1	2	2	1	1	1	1	2	1	1	—
Peshawar ...	1	2	2	1	1	1	1	2	1	1	—
Mardan ...	—	—	—	—	—	—	—	—	—	—	—
Hazara ...	—	—	—	—	—	—	—	—	—	—	—
D. I. Khan Division	1	2	1	1	1	1	2	2	2	2	—
Bannu ...	—	1	—	—	—	—	—	1	—	—	—
D. I. Khan ...	1	1	1	1	1	1	2	1	2	2	—
BALUCHISTAN	—	—	—	—	—	—	—	b	b	b	—
Quetta Division	—	—	—	—	—	—	—	—	—	—	—
Quetta ...	—	—	—	—	—	—	—	—	—	—	—
Loralai ...	—	—	—	—	—	—	—	—	—	—	—
Kalat Division	—	—	—	—	—	—	—	—	—	—	—
Kacchi ...	—	—	—	—	—	—	—	—	—	—	—
Kalat ...	—	—	—	—	—	—	—	—	—	—	—
Mekran ...	—	—	—	—	—	—	—	—	—	—	—
Lasbella ...	—	—	—	—	—	—	—	—	—	—	—

Source :— Ministry of Agriculture, Government of Pakistan.
N.B.—Break-up may not add upto total due to rounding off.
b—Below one thousand.

Table 9 —DESI COTTON YIELD

Province/Division/ District	66-67	67-68	68-69	69-70	70-71	71-72	72-73	73-74	74-75	75-76	76-77
1	2	3	4	5	6	7	8	9	10	11	12
					(Lbs. per acre)						
PAKISTAN	149	156	144	160	179	203	198	201	189	177	N.A.
PUNJAB ...	136	149	136	155	169	179	153	170	150	148	—
Rawalpindi Division	123	115	143	106	157	131	147	173	107	85	—
Campbellpur ...	—	—	—	—	—	—	—	—	132	—	—
Rawalpindi ...	—	—	—	—	—	—	—	—	99	—	—
Jhelum ...	131	112	105	113	196	—	—	209	119	86	—
Gujrat ...	147	147	174	118	168	131	147	164	102	90	—
Lahore Division	131	136	152	144	152	173	127	153	145	158	—
Sialkot ...	105	131	175	127	131	140	140	137	132	118	—
Gujranwala ...	131	157	178	139	131	157	137	136	136	118	—
Sheikhupura ...	131	157	228	143	157	196	134	131	132	149	—
Lahore ...	142	132	132	151	162	180	123	159	151	173	—
Sargodha Division	121	144	160	154	162	174	154	156	135	124	—
Lyallpur ...	157	176	163	181	162	176	157	157	138	131	—
Sargodha ...	147	118	201	131	131	196	180	180	198	175	—
Jhang ...	—	—	—	—	—	196	157	142	206	181	—
Mianwali ...	65	112	102	119	196	137	128	144	99	87	—
Multan Division	165	131	170	147	196	180	158	162	145	124	—
Sahiwal ...	131	121	192	149	235	214	164	164	151	124	—
Multan ...	174	147	174	174	168	196	165	164	154	131	—
Muzaffargarh ...	157	157	125	133	196	131	151	166	132	111	—
D. G. Khan ...	196	96	—	114	—	—	137	147	148	131	—
Bahawalpur Division	142	168	112	174	187	192	179	190	176	162	—
Bahawalpur ...	131	143	128	135	131	178	178	171	82	70	—
Bahawalnagar ...	142	172	110	178	189	194	181	192	181	169	—
Rahimyar Khan...	196	196	—	—	261	196	—	112	206	157	—

Continued

Continued

Province/Division/ District	66-67	67-68	68-69	69-70	70-71	71-72	72-73	73-74	74-75	75-76	76-77
1	2	3	4	5	6	7	8	9	10	11	12
					(Lbs. per acre)						
SIND ...	**170**	**169**	**160**	**160**	**210**	**258**	**329**	**288**	**269**	**254**	**N.A.**
Khairpur Division	**178**	**169**	**158**	**175**	**210**	**258**	**329**	**288**	**268**	**254**	—
Khairpur ...	184	187	143	124	141	247	329	344	246	274	—
Jacobabad ...	—	131	127	—	—	—	—	—	263	—	—
Sukkur ...	180	166	164	—	—	—	—	—	296	—	—
Nawabshah ...	179	165	163	202	234	260	329	352	271	247	—
Larkana ...	—	—	—	—	—	—	—	—	—	263	—
Hyderabad Division	**146**	**171**	**176**	—	—	—	—	—	**278**	—	—
Hyderabad ...	123	188	162	—	—	—	—	—	323	—	—
Tharparkar ...	174	147	165	—	—	—	—	—	392	—	—
Sanghar ...	168	131	206	—	—	—	—	—	—	—	—
Dadu ...	—	—	—	—	—	—	—	—	245	—	—
Thatta ...	—	196	216	—	—	—	—	—	263	—	—
N.W.F.P. ...	**157**	**196**	**196**	**166**	**157**	**171**	**196**	**186**	**181**	**196**	—
Peshawar Division	**131**	**196**	**196**	**163**	**196**	**165**	**179**	**180**	**189**	**178**	—
Peshawar ...	131	196	—	—	196	171	166	178	198	178	—
Mardan ...	—	—	—	—	—	—	196	196	198	—	—
Hazara ...	—	—	—	—	—	—	—	196	197	—	—
D. I. Khan Division	**196**	**196**	**196**	**178**	**131**	**176**	**179**	**191**	**181**	**182**	—
Bannu ...	—	392	—	—	—	—	224	211	140	147	—
D. I. Khan ...	196	131	196	178	131	176	172	182	198	190	—
BALUCHISTAN	—	—	—	—	—	—	—	**294**	**173**	**261**	—
Quetta Division	—	—	—	—	—	—	—	—	—	—	—
Quetta ...	—	—	—	—	—	—	—	—	—	—	—
Loralai ...	—	—	—	—	—	—	—	—	—	—	—
Kalat Division	—	—	—	—	—	—	—	**261**	—	—	—
Kacchi ...	—	—	—	—	—	—	—	261	—	—	—
Kalat ...	—	—	—	—	—	—	—	—	—	—	—
Mekran ...	—	—	—	—	—	—	—	—	—	—	—
Lasbella ...	—	—	—	—	—	—	—	—	—	—	—

Source :— Ministry of Agriculture, Government of Pakistan.

APPENDIX

TABLE NO. 10

National, Provincial and Varietal Yields of Lint in Pakistan for the Crop Seasons 1972-73 Through 1975-76[1]

Variety	Yield by Seasons[2] 1972-73	1973-74	1974-75	1975-76	Average (4 seasons)
Pakistan (All)	321	328	288	254	298
Sind (All)[3]	422	404	368	331	381
Punjab (All)	294	303	261	228	272
AC - 134	303	308	268	234	278
L.S.S.	276	227	187	167	214
149-F	202	313	265	247	257
124-F	330	330	261	229	288
B.S.I.	278	276	246	211	253
MS 39/40	392	392	261	-	348
AC 307	271	273	225	189	240
N-F	266	251	226	196	235
Deltapine	315	323	269	249	289

(1) Data taken from Cotton Statistical Bulletin, Vol. 6, No. 2, pp. 19-20, published by Pakistan Central Cotton Committee, Karachi.

(2) Unfortunately varietal data for 1976-77 (the season of greatest total national yield decline) in the form given here, were unavailable.

(3) Inferred from original tables from which these data were taken.

Fig. 1

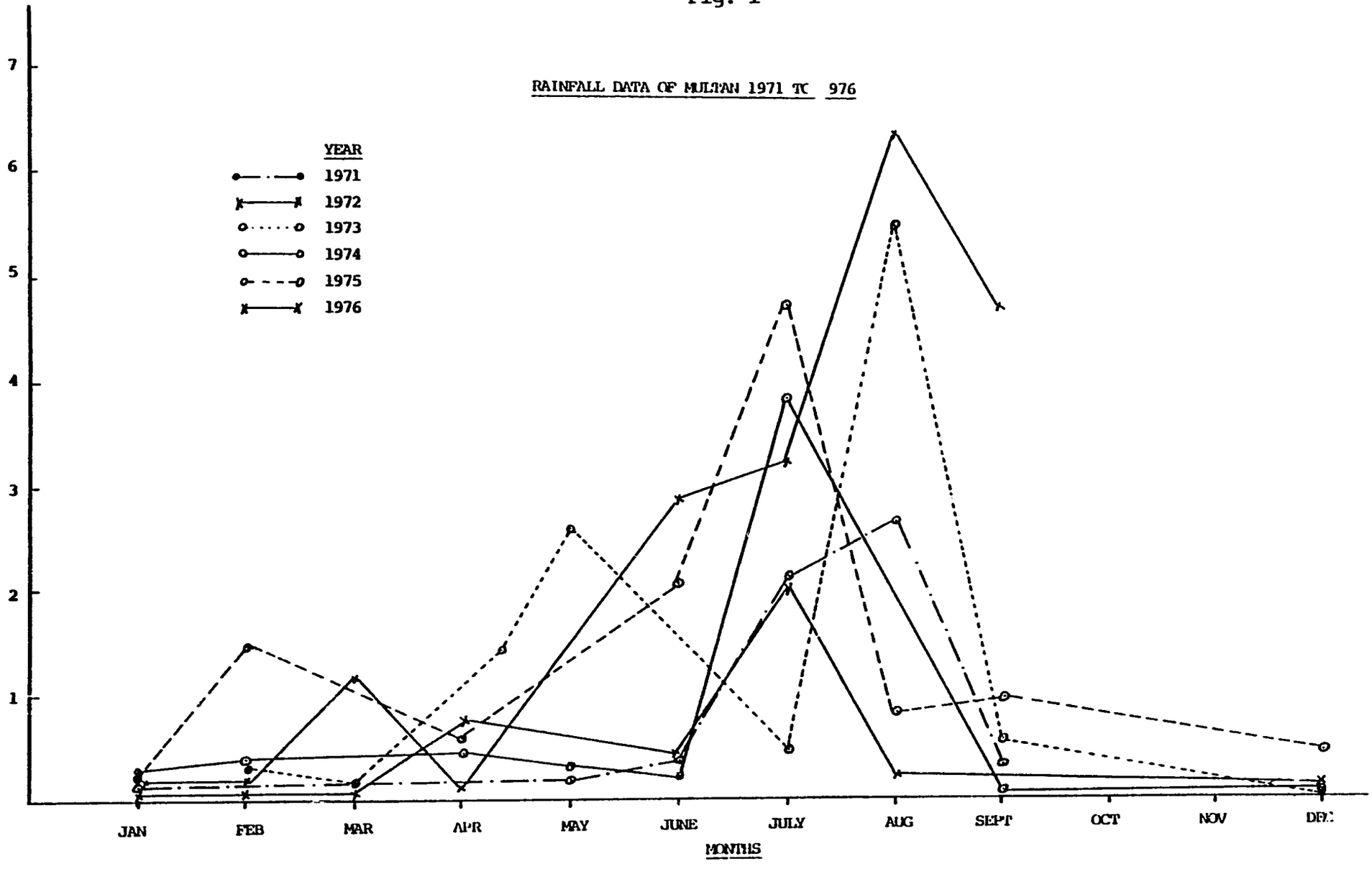

RAINFALL DATA OF MULTAN 1971 TO 976
YEAR
1971
1972
1973
1974
1975
1976
7
6
5
4
3
2
1
JAN
FEB
MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
MONTHS

Fig. 2

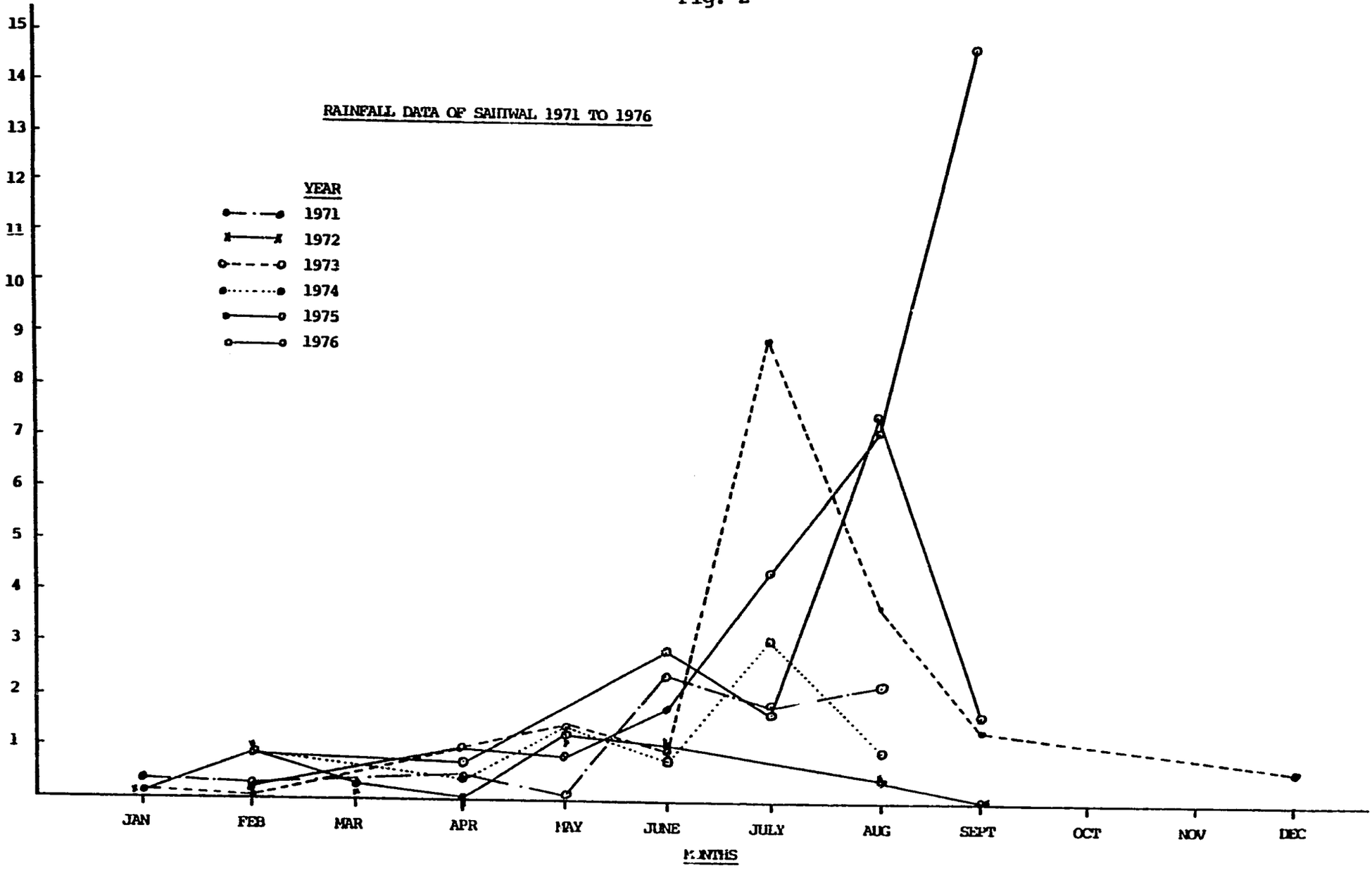

RAINFALL DATA OF SAHIWAL 1971 TO 1976
YEAR
1971
1972
1973
1974
1975
1976
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
JAN
FEB
MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
MONTHS

Fig. 3

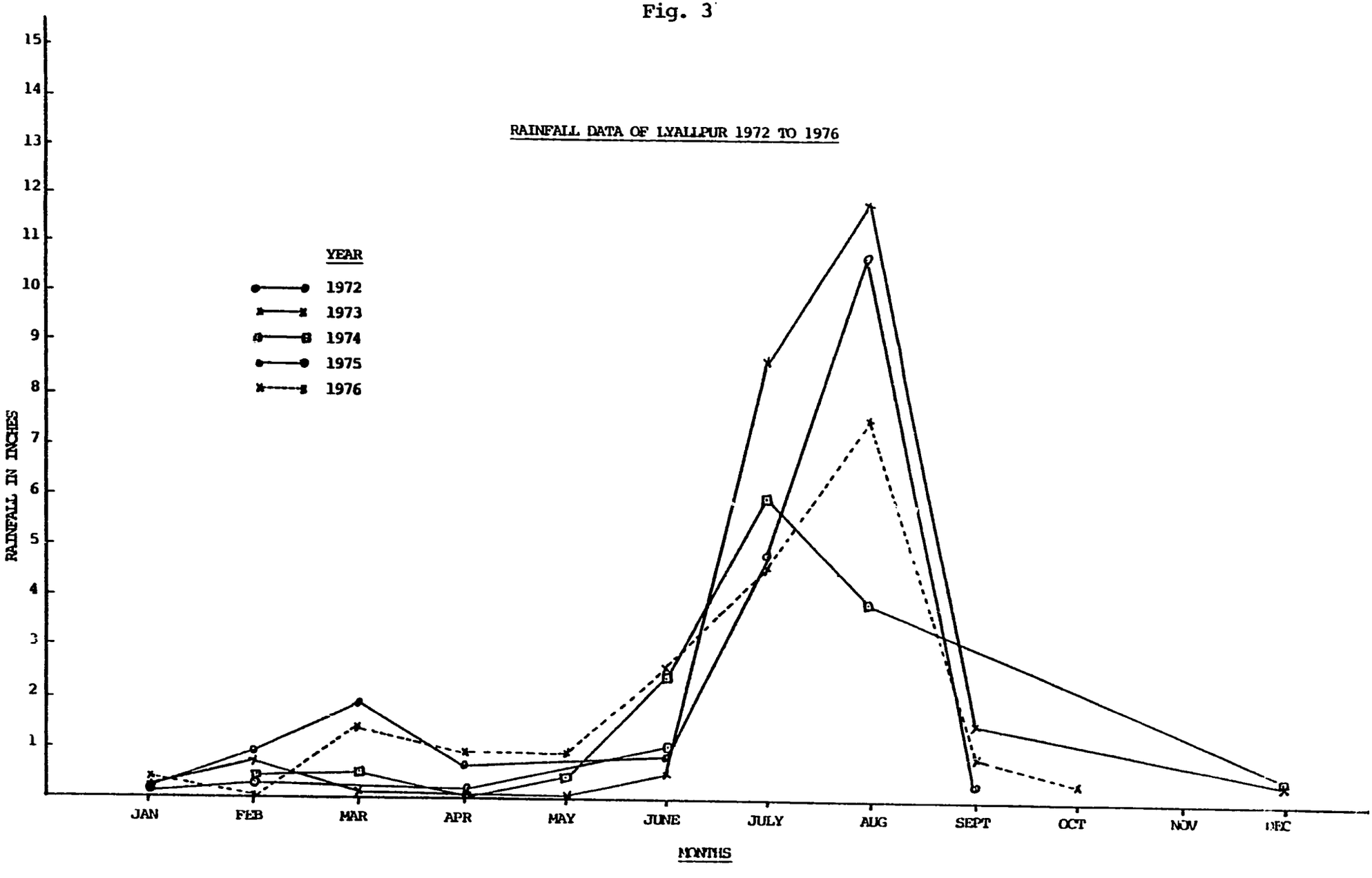

RAINFALL DATA OF LYALLPUR 1972 TO 1976
YEAR
1972
1973
1974
1975
1976
RAINFALL IN INCHES
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
JAN
FEB
MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
MONTHS

Fig. 4

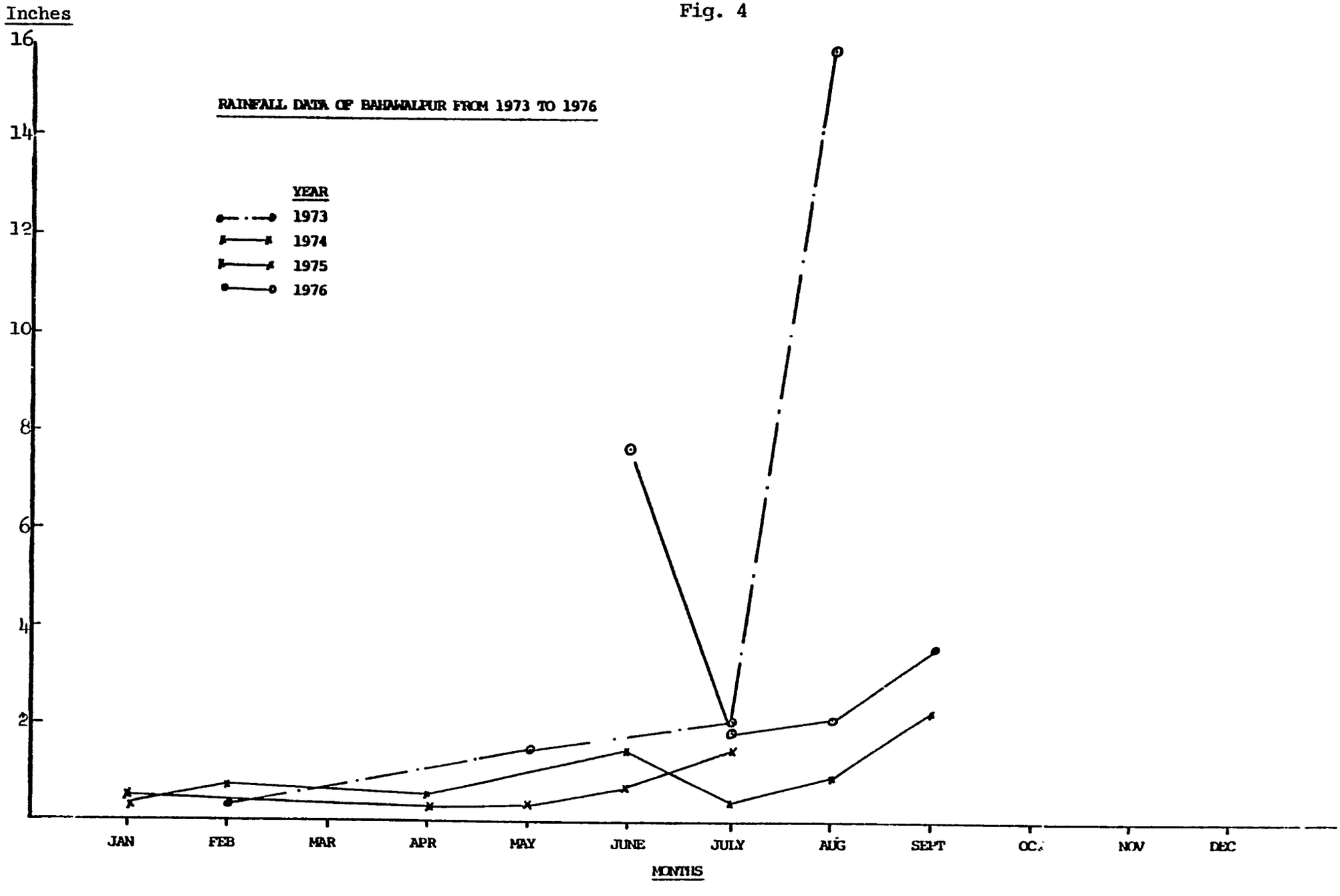
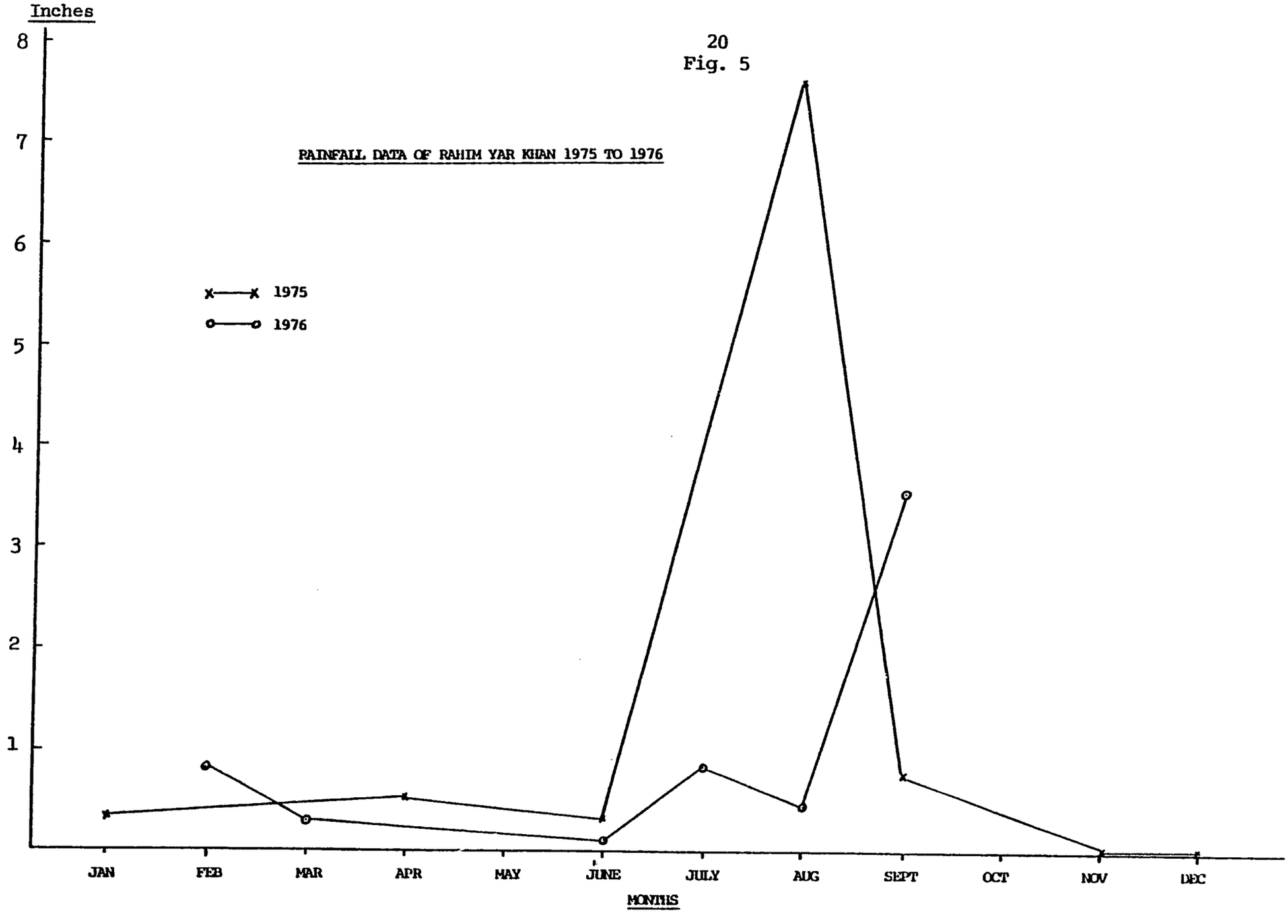

Inches
16
14
12
10
8
6
4
2
RAINFALL DATA OF BAHAWALPUR FROM 1973 TO 1976
YEAR
1973
1974
1975
1976
JAN
FEB
MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
MONTHS

Fig. 5


RAINFALL DATA OF RAHIM YAR KHAN 1975 TO 1976
Inches
8
7
6
5
4
3
2
1
1975
1976
JAN
FEB
MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
MONTHS

ADDENDUM

In conferences with Pakistan and USAID officials during a review of this report, requests were made for further information on certain subjects. The following discussions on insects are additions to those already contained in the text.

1. Granular insecticides. Several insecticides are formulated as granules for seed treatment, infurrow application at planting time, or for side dressing. They are absorbed by the roots and translocated throughout the plant. The insecticidal action may persist for several weeks in the plant. Certain sucking insects feeding on the plant, such as thrips, aphids, and spider mites, may be killed and there is evidence that some species, including beneficial insects, are killed by fumigation action from the granules. Phytotoxicity is a problem under certain conditions, particularly when seed treatment is used. Aldicarb, disulfoton, and phorate are recommended for use in the U.S. All are toxic to man and animals and should be used with proper caution. Since granular insecticides are more easily applied than sprays or dusts, they may be especially useful in Pakistan. They are used to some extent in the U.S.

2. Aerial application. Insecticides have been applied from airplanes for the control of cotton insects in the U.S. since 1922. It was found many years ago by Gaines and others that dusts and sprays were equally effective whether applied from airplanes or ground machinery. Frequently, a grower will use ground machinery while the cotton is small and finish the season with airplane applications. Under some conditions where trees, power lines, buildings, or other obstacles prevent the use of fixed wing airplanes, helicopters will be used, but they are slower and more expensive to operate. In Pakistan we were told that only about 200,000 acres of cotton land is suitable for airplane treatment because of obstacles and small fields. Even though this is

a small percentage of the total acreage planted in cotton, it should be treated by airplanes in the most efficient and effective manner. One decided advantage of airplanes or helicopters is that they can treat broadcast cotton as effectively as that planted in rows. The important consideration is to get full coverage with the proper insecticide, when needed, based on field inspections. It makes little or no difference whether it is applied by airplane or ground machinery, in spray or dust form.

3. Threshold when control is needed. The insect infestation level which justifies the use of insecticides is seldom constant for all locations and conditions. It depends on size and stage of plant growth, potential productivity of the crop, and other factors. The threshold of injury for a pest has usually been determined by research entomologists working on practical field control of insects over a long period of time. A thorough knowledge of the cotton crop, good judgement and common sense are required to determine when it is profitable to apply insecticides to control insects. In the U.S. each state makes its own recommendations for cotton insect control, basing them on applicable research data, local cotton growing conditions, and past observations of insect damage in the area. When to begin and repeat applications of insecticides is based on insect counts and injury to plants, keeping in mind that cotton can tolerate some insect injury before insecticides can be profitably used.

4. Heat treatment and fumigation of planting seeds. Heat treatment of cottonseed in the gin to kill hibernating pink bollworms was discontinued in Texas about 1957. It was found that passing seed cotton through modern gins was sufficient to kill practically all of the hibernating larvae which passed the winter in seed cotton left in or near fields which they developed. The planting of untreated seeds within the infested area is considered to be of little importance. However, fumigation or other prescribed quarantine treatments are required before

seeds can be moved into noninfested areas.

The best place for pink bollworms to pass the winter is in unharvested bolls which are kept over winter in dry places, such as on the surface of the soil, standing stalks in the field, or on stalks stored for fuel. On the other hand, plowing under the infested bolls in moist soil soon after harvest is one of the best methods for controlling the pink bollworm. These observations were confirmed in talking with the entomologists at Multan.

We do not believe that heat treatment or fumigation of planting seeds in Pakistan is justified, since all cotton producing areas of the country are infested and there is no danger of further spread through movement of infested seeds.

5. Biological control. Insect parasites, predators, and pathogens under optimum conditions maintain a biological balance with insect pests and may prevent economic damage to cotton. This ideal balance seldom exists because of weather conditions. Attempts have been made to rear and release large numbers of parasites and predators to control destructive cotton insects. Some success has been achieved, but usually it is necessary to resort to insecticides since conditions which limit the natural populations also affect those released. Usually the main return from introducing additional parasites or predators is to gain a slight delay in starting the application of insecticides. Other methods of biological control being investigated in the U.S. are: male sterile technique, genetic control, use of hormones, and attractants. While these methods may have promise for use against certain insects, they are not yet ready to be recommended to farmers for cotton insect control. The pink bollworm sex lure is promising and may have a role to play controlling overwintering pink bollworms. The use of insecticides is only a part of integrated control or pest management programs. Economic or applied entomologists have always considered all approaches to insect control and as a last

resort turned to insecticides to prevent crop losses.

6. Need for treatment of all fields. The question is often asked if one farmer can profitably control cotton insects if the adjoining fields are not treated. The answer is "yes". While it is true that most insects move about within an area, it is possible to get economical control on an individual field basis. The residual toxicity of most insecticides gives control for several days and applications are usually repeated at 5 day intervals to maintain full protection until the pests are brought under control.

7. Scouting cotton fields. This subject is briefly discussed under the heading "Determining need for insect control" but will be elaborated on here. In the U.S. checking or scouting cotton was started many years ago by commercial concerns which sold insecticides or provided application services. Many such companies still continue this free service as part of their sales program. Some farmers suspected that the industry scouts were biased in their observations and recommendations and so private entomologists went into the cotton scouting business. They usually contract with a grower to make infestation records on a 5 to 7 day schedule throughout the season for a specified amount, usually $1 to $3 per acre, depending on the number of fields and acreage covered. The scout may make recommendations to the grower, or he may provide the infestation records and let the grower decide what action he will take.

   In some cases an aggressive scout will employ students or teachers during the summer to help make the field infestation records after being trained and under his close supervision. He will then report the findings to the farmer. This procedure makes maximum use of the qualified cotton entomologists, trains scouts, and still provides responsible field checking.

   It is difficult to design a scouting system where fields are extremely

small. If infestation records are made in every field the acreage a scout can handle would indeed be small. Selecting random fields throughout an area for examination would be more efficient, but the accuracy of the program would be somewhat lowered and the individual farmer whose field was not checked would likely refuse to pay for the service.

It is strongly suggested that a scouting program be started in a few locations where progressive farmers would be involved. If successful, it could easily be expanded in future years. Experience in the U.S. has shown that such programs financed and carried out by growers are far more likely to succeed than where they are in the hands of the government.

In the U.S. it is the government's responsibility to regulate and register approved insecticides, conduct needed research on cotton insects, and carry out an effective extension program. Each state extension service issues guides for controlling cotton insects and often conducts training courses for cotton scouts. The recommendations include suggestions as to when to start insecticide applications, materials to use, and interval between applications. Private industries sell insecticides to farmers and may advise them on the need for insecticides, based on their own free inspection of fields. Industry also provides airplane and ground application service. The farmer makes his own decision as to what, if anything, to do to his crop and hopefully make a profit. He should be aware that insect control itself does not increase yields but only protects the potential yield that the crop has. He should do everything possible to produce a high yielding cotton crop and then protect it from destructive insects.